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Portuguese Awareness of Electric Vehicles' role on Energy Transition

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"It always seems impossible until it's done"
Nelson Mandela

Abstract

Recently, the environmental crisis cannot be denied, following the climate changes that have been taking place. We are currently undergoing an energy transition, which aims at a wider use of renewable energies. Focusing on the transports sector, Electric Vehicles are seen as the best solution to carry out this transition.

Thus, this research aims understanding if there is a complete level of awareness about the role of Electric Vehicles in the energy transition by the Portuguese population.

From the survey applied to people over 18 years old living in Portugal, 151 answers were registered. 61.6% own a Conventional Vehicle and only 6% own an Electric Vehicle.

The study concluded that the sample is moderately aware of Electric Vehicles, as they have knowledge about their acquisition, but have doubts about their engines and the costs of circulation. Additionally, a large part of the sample considers Electric Vehicles to be critical for the energy transition, although there is a lack of knowledge about their specific impacts. Finally, we concluded there is a sense of change in more than 50% of the sample, considering it may increase as long as people are more interested in Electric Vehicles and are more likely to acquire one in a next buying.

The awareness of Electric Vehicles is critical in this context, as it is the catalyst for the population's perception of importance and to be the facilitator of the sense of availability to switch vehicles, alongside with government incentives and improved purchasing power of the population.

Keywords: Electric Vehicles, Energy Transition, Consumer Awareness, Portugal

JEL Classification: O130, Q40, Q5

Resumo

Ultimamente, não pode ser negada a crise ambiental, na sequência das alterações climáticas que se vêm a verificar. Atualmente, passamos por uma transição energética, que visa uma utilização mais alargada de energias renováveis. Focando no setor dos transportes, os Veículos Elétricos são vistos como a melhor solução para levar esta transição a cabo.

Assim, esta investigação objetiva perceber se existe um nível completo de consciência sobre o papel dos Veículos Elétricos na transição energética pela população portuguesa.

Do questionário aplicado a indivíduos com mais de 18 anos de idade com residência em Portugal, 151 respostas foram registadas. 61.6% possuem um Veículo Convencional e apenas 6% possuem um Veículo Elétrico.

Concluíu-se que a amostra é moderadamente consciente sobre os Veículos Elétricos, dado terem conhecimento sobre a sua aquisição, mas apresentarem dúvidas sobre os motores e custos de circulação. Adicionalmente, grande parte da amostra considera os Veículos Elétricos críticos para a transição energética, embora se verifique falta de conhecimento sobre os seus impactos específicos. Finalmente, verificou-se um senso de mudança em mais de 50% da amostra, sendo que poderá ser mais elevado quanto maior for o interesse das pessoas nos Veículos Elétricos e seja mais provável para si a aquisição de um numa próxima compra.

A consciência sobre os Veículos Elétricos é crítica neste contexto, porque é a catalisadora da perceção de importância pela população e é facilitadora do sentimento de disponibilidade para a mudança de veículos, a par dos incentivos do Estado e da melhoria do poder de compra da população.

Palavras-Chave: Veículos elétricos, Transição energética, Consciência do consumidor, Portugal

Classificação JEL: O130, Q40, Q5

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List of Abbreviations

ACAP | Associação Automóvel de Portugal

BEVs | Battery Electric Vehicles

CV(s) | Conventional Vehicle(s)

CO_2eq | Greenhouse Gas emissions equivalently to CO_2 emissions

EC | European Commission

EEA | European Environment Agency

EIB | European Investment Bank

ER-EVs | Extended-Range Electric Vehicles

EU |European Union

EV(s) | Electric Vehicle(s)

FCEVs | Fuel Cell Electric Vehicles

GDP | Gross Domestic Product

GHG | Greenhouse Gas

HEVs | Hybrid Electric Vehicles

ICE | Internal Combustion Engine

MAAC | Ministério do Ambiente e Ação Climática

MATE | Ministério do Ambiente e da Transição Energética

ML | Maximum Likelihood

PHEVs | Plug-in Hybrid Electric Vehicles

RES | Renewable Energy Sources

RNC | Roadmap to Carbon Neutrality (Roteiro para a Neutralidade Carbónica)

SDG | Sustainable Development Goals

UN | United Nations

UNEP | United Nations Environment Programme

WEF | World Economic Forum

WTW | Wheel-to-Wheel

1 | Introduction

1.1 | Overview

Every step we take in our academic path is a new opportunity for us to acquire new skills, develop the existing ones, get diverse knowledge, and try to leave our mark in our area of studies. On a master's degree, we know it is the time to investigate new topics, add and improve the existing theories or test and compare new insights.

Regarding the subject of this study and, inherently, its specificities, this Dissertation is going to be focused on the topic of the Portuguese awareness of electric vehicles' role on energy transition, considering the European Union (EU) goals for climate-neutrality for 2050 (European Commission (EC), 2018).

1.2 | Research Problem

In the last years, we cannot deny the environmental crisis is an imminent and current issue of the modern society and every country, every government and every person know something must be done. In fact, the climate change has been taking a great role in some of the policies created and aligned for the next generations, in different economic sectors. Regarding the transports sector, electric vehicles (EV) are seen as the best solution, since they "have the potential to improve the efficiency, affordability, and sustainability of the transport system" (Ortar & Ryghaug, 2019).

Along with the so known Sustainable Development Goals (SDG), where we find a bunch of wished transformations and transitions until 2030, the EU brought up the long-term strategy for 2050 in 2018 – it aims to become "an economy with net-zero greenhouse gas emissions." (EC, 2018) – the so-called climate-neutral economy. These new objectives are in line with the global climate action needs in Paris Agreement, as well as with the European Green Deal. These goals for the European societies must be seen as a challenge that will not be easy to accomplish in the next years, but they also need to feel as a 'full teamwork', since everyone will need to adjust their behaviors, in order to construct a better perspective for the world. Furthermore, each economic sector is going to play a great role in this transition, as we are promoting the zero emissions and neutrality. It is time to become "greener" than before, and several domains like industry, construction, and agriculture, besides others, will need to step up and adapt their common processes.

In Europe, lots of solutions have been approached and thought about and, in fact, there is a chance of leading this transition "by investing into realistic technological solutions,

empowering citizens and aligning action in key areas such as industrial policy, finance and research, while ensuring social fairness for a just transition." (EC, 2018), with impacts in each activity sector.

Among other sectors, according to the 2017 European Environment Agency (EEA) data, the CO_2 emissions from the transports sector have been increasing in the last years, being the road transports the most polluting ones (around 72% of the transports sector' emissions). In addition, more recently, data retrieved from PORDATA confirm that the transports sector accounts for one of the largest amounts of greenhouse gas (GHG) emissions in the European Union in 2020 (around 22%). Therefore, cars come up as the vehicles that pollute the most, achieving 60,7% of the on-road emissions to the atmosphere (EEA, 2017). For these bad effects to be decreased, two things can be done: to create and produce more efficient vehicles and change what fuels them. Hence, EVs have been gaining space in the automotive sector purchasing. Nevertheless, when considering the total CO_2 emissions produced by a car, it is necessary to consider both the emissions during the circulation and in the producing and disposing process, regarding that this process is less eco-friendly on EVs than on CVs. However, EVs have been proving they are one of the cleaner and "greener" paths to adopt in the future, since it is foreseeable there will be a strong increase on the energy from renewable sources and, thus, EVs will be less damaging for the environment comparing to petroleum-based fueled ones.

In fact, one of the EU goals is to transform the whole mobility into electric mobility, along with the transition for green energies. The EU's goals for 2050 are to stop producing fossil fuel-powered cars from 2035 onwards and, gradually, put more EVs in circulation and, from 2050 on, only electric cars can be for sale and on the roads in Europe (Observador, 2021).

This will be a great change in people's lives. Nevertheless, and considering Portugal only, from 2035 onwards there will be gradually only one choice for people when buying a vehicle. Some questions do start to pop up: Do people want to switch cars? Do people have the purchasing power to do so? Will they have the resources and structures to do so? And what will happen from then on with fossil fueled cars? - will brands no longer have procedures to repair non-EVs? - does that mean the population will be forced to switch cars? Will we have more public electric charging locations?

But, more than understanding if there will be structures to implement and go on with this transition, one bigger question is: Are people aware of how this change is important for the planet?

According to the fourth edition of the European Investment Bank (EIB) survey (2022) about climate, the Portuguese population is the leader in EU, regarding the purchasing intention of EVs, being 17 p.p above the European average, with 84% declaring they prefer a hybrid or an

EV in the next purchasing car. This fact suggests that Portugal is available to take a part in this transition and to be an accelerator of it. Nonetheless, there is still 40% of the population that intends to buy a hybrid, which, as known, is a vehicle with both a combustion engine and an electric engine and, inherently, is going to cause a greater pollution, when comparing to EVs. Different types of EVs lead to different impacts on energy transition and it is crucial that every consumer must be aware of these implications.

In this sequence, the EU asked every state-member to conceive a specific national long-term strategy for their own case, concerning the way each country plans to reduce GHG emissions, with respect to every national activity sector, so that commitments under EU goals and Paris Agreement can be achieved. In 2019, Portugal developed the Roadmap to Carbon Neutrality in 2050, an extensive document, which explains the planning for the future and how every domain will need to behave and how the transition will be led.

However, even though there are estimates, prospects and real data that tell the Portuguese people want to change, the question that arises is: Are they fully aware of the different impacts of using different types of EVs on energy transition? Are they aware of the different advantages, as well as the disadvantages, so that they can choose wisely and consciously? There is a lack of studies concerning the Portuguese awareness on these matters. We found out, after the literature review, there is a great purchase intention in Portugal regarding EVs, but the EVs sales don't follow this trend, as one of the greatest barriers to buy an EV is the lack of consumer awareness or knowledge. We will study this topic to perceive if there is a complete awareness of EVs in Portugal and the potential cause for this slow growing trend, due to the lack of investigations associated with the matter.

This study will focus on people's awareness regarding EVs and will try to understand what it takes for the Portuguese population to decide about how to go on with these changes in the economy, namely in what comes to changing their consumer behavior in the mobility sector. We will try to understand how they perceive EVs and their differences, as well as to consolidate the conclusions about the purchasing intentions for the next years, until 2050.

This is a relevant topic to investigate since it is about a new sustainable way of development and living and thus, unavoidably, it involves populations. Each decision will have a different impact and since Portugal is expected to fully agree that a change in the consumer and personal behaviors has to be done, populations should be 100% involved and in possession of 100% of the information.

1.3 | Research Goals and Questions

This study has a major objective. Following the EU specific goal of transiting to a full adoption of EVs in 2050, gradually beginning in 2035, we want to understand if there is a complete level of awareness in the Portuguese population about the EVs on the energy transition.

For that purpose, we have defined three specific goals. Firstly, we want to perceive the Portuguese consciousness of the differences between different types of EVs. Secondly, we aim to find out what is the Portuguese awareness of the outcomes of the adoption of each EV type. Lastly, there is a need to figure out if there is a sense of inner change and real availability in the Portuguese population for the energy transition on the mobility sector, understanding the trends of the consumer behavior and the consumer's perception, considering what they think are the constraints of buying these vehicles.

In fact, the purpose of this thesis is to know the real Portuguese awareness of EVs' role on energy transition. For that, there is a need to settle the questions that will lead the study and enable us to achieve our research goals, with more detailed and precise results, anchored in the literature review.

a) To what extent are the Portuguese conscious about EVs?
b) Are the EVs perceived as critical for the energy transition, by the Portuguese population?
c) Is there a sense of inner change in the Portuguese population, regarding EVs adoption in the context of energy transition?

1.4 | Study Structure

This study presents five chapters, divided into sub-chapters.

Firstly, in the Literature Review, the reader will be able to get the theoretical ideas and frameworks that give foundation and support to the topic in analysis, regarding the points of view from several authors. It will be shown empirical evidence and arguments on important themes for this study, such as Climate Change, Green Economics, Electric Vehicles and their differences, the EU SDG, as well as its goals for achieving climate-neutrality by 2050.

Then, considering Data and Methodology, we will create a survey focusing on the Portuguese consciousness and knowledge about the EVs, with questions regarding different dimensions. Afterwards, it will be explained the data collection context. We will also detail our instruments and methods and describe our sample. After this, the results will be evaluated and we will develop two econometric models, to make inferences on our study.

In the Empirical Analysis and Discussion chapter, it will be provided an interpretation of our study outcomes and their impact on the EVs topic, giving a summary review on it in the

Conclusion and Recommendations chapter. Finally, the limitations of the study and the suggestions for future research are approached in the Limitations and Future Research chapter.

2 | Literature Review

2.1 | Overview

In this section, we will follow a rational thinking through different topics that lead to our research questions. To evaluate the current awareness of the adoption of EVs, we need to understand what brought us to the current stage. Starting from the climate change and the consequential consciousness about Green Economy, the reader will be able to perceive how a sustainable development may be achieved through EVs and how, through the European Goals for 2050, they contribute for the problematic in study.

2.2 | Green Economy and Sustainable Development

In the last years, we have been experiencing a climate crisis. According to Fawzy et al. (2020), climate change may be defined as a mutation in weather patterns, which is primarily caused by GHG emissions, bringing up heat and an ongoing rise of its concentration on the Earth's atmosphere (Sanneh, 2018). Effectively, this is what is causing the so-called global warming. The current climate change status is not positive (Fawzy et al., 2020), as there are several sources of emissions like natural systems, that include forest fires, earthquakes, wetlands, volcanoes, among others (Yue and Gao, 2018), and human activities, as industry, energy production and land-use (Edenhofer et al. 2014). Consequently, these sources result in impacts on every sector, cause several risks, and bring some vulnerabilities. All over the world, it is observed a great change in climate, focusing on temperature, the sea-level rising and diverse and extreme weather conditions, which provoke different and serious natural disasters, such as floods, heatwaves, landslides, storms, etc. (UNCCS, 2019 quoted by Fawzy et al., 2020). Regarding risks, climate change has been raising dilemmas. Besides the impacts on ecosystems, we may understand that, for instance, food, health, water, infrastructure, and human *habitat* are several features in great risk, namely for the African continent. Besides, there are crucial vulnerabilities on key economic sectors as transportation, tourism, and energy, not neglecting the imminent risk of life loss, not only human, but also animal. According to the 2020 Global Risks Report from the World Economic Forum (WEF), the climate change can cause possible geopolitical conflicts, as well as financial impacts, in addition to supply chains and trade relations risks (WEF, 2020).

Most of these changes result from human activities. To solve this global issue, many conventions and agreements have been coming up with the goal of bringing a consensus to the table on how to react and, inherently, there are some climate change mitigation strategies approached on the literature. These comprise not only the use of conventional ways, but also recovering new technologies and techniques, so that the GHG emissions can be reduced (Fawzy

et al., 2020). Concerning the demand and supply of energy, the mitigation technologies pointed out are Renewable Energy, Nuclear Power, Carbon Capture and Storage/Utilization and Fuel Switch, followed by efficiency gains. In the literature it can be also found "end-use fuel switch from fossil-based fuels to renewable fuels, and, moreover, the integration of renewable power technologies within the energy matrix of such sectors" (Mathy et al. (2018), Hache (2015), quoted by Fawzy et al., 2020).

There can be different approaches to overcome the climate change, as renewable energy may be a differentiator, regarding the permanent and solid action on this sector. The world has been working on the development of a, not already new, concept of Green Economy, which is commonly referred, in the literature, as having the same meaning as Green Economics. According to Constantinescu & Frone (2019), there is a great answer to the current climate crisis – "Transition to a new economic system based on sustainable development". Hence, the Green Economy concept is defined by the authors as a sustainable option to economic growth, accounting for the improvement of the population's quality of life. Nevertheless, this is a notion that has been being investigated and approached for long years and it is important to understand a worldwide accepted definition – Green Economy is a process able to "contribute to improving the well-being and social equity, while significantly reducing environmental risks and ecological deficits" (UNEP, 2011), regarding the protection of natural resources and the promotion of an eco-friendly economic development. Constantinescu & Frone (2019), considering the EEA (2011) information, show what are the center elements of a Green Economy, which converge to a strategy mindset, where every investment in this field should promote renewable energy technologies, as well as support forest and water sustainable management, provide a proper waste management and ensure energy efficiency. Furthermore, mobility, industry and innovation are also in the center of this concept.

However, earlier, Loiseau et al. (2016) argued that "green economy covers a lot of diverse concepts and its links with sustainability are not always clear". Yet, the authors say that we can look simply to the concept and perceive it as "being low-carbon, resource efficient and socially inclusive", including the preservation of natural capital (natural resources and ecosystems). In this way, Green Economy concept can be summarized as an 'umbrella' that contemplates diverse effects about well-being and growth, regarding the "efficiency and risk reduction in the use of natural resources" (Loiseau et al., 2016: page 362). According to these authors, there are several theories, approaches, tools and concepts for a Green Economy.

Firstly, environmental economics and ecological economics are two sub-areas that have been arising more and more in the green economics field, as they spot out the inefficient use of

natural resources and the urgent need to change the humankind mindset, not only in the populations day-to-day, but also on the business and entrepreneurial relations.

Secondly, since the beginning of the century, there were often different tips that intended to change population's behavior towards consuming, that didn't seem to promote green economics, but effectively were. For example, the reduction of plastic utilization, as well as the waste hierarchy were topics to which was tried to raise awareness, which we commonly known as 3 R's (Reduce, Reuse, Recycle). Loiseau et al. (2016) argue that this approach, along with waste prevention, "are important elements of green economy by improving resource efficiency, reducing the need for raw materials and aiming at closing the material flows".

In addition, circular economy has been gaining popularity in the contemporaneous society, as Hill (2015) stated that it builds on waste prevention and resource efficiency for two sides: On one hand, it shows where greatest benefits may be brought up and, on the other hand, it emphasizes "the need to consider the sustainability of the sources of raw materials, as well as their fate". Afterwards, new concepts and approaches may be seen as cleaner production and resource efficiency, life cycle and material flow-based tools and methods or cost-benefit analysis.

Loiseau et al. (2016) clarified green economics by integrating all the elements, concepts and approaches in a "multi-layered framework", and also considering the general benefits of it. (See Annex A, Figure A.1.).

Kasztelan (2021: page 4) concluded that "The transition to a green economy is a multi-step process contributing to achieving the long-term objective", which is the sustainable development and, inherently, every data regarding green economics will be a powerful aspect to shape future country development strategies, stimulating changes. In contrast, Dogaru (2021) defends that Green Economy implies the need to cut down environmental risks, as well as ecological deficit, considering that this concept raises different interpretations regarding "resource efficiency through the implementation of innovative approaches designed to optimize resource consumption and reduce pollutant emissions." In fact, Green Economy also demands a sustainable approach to resources, preserving natural capital and ecosystems. Summarizing, Green Economy is directly connected to sustainable development, having a common denominator – the environmental protection, which increases the competitiveness and productivity of the available assets to the economy (Dogaru, 2021), not neglecting that this is a long-term process and that it involves commitment from all the interested parts, namely from the member states to change their economic development model. This author argues that "this process involves initiatives related to public involvement in implementing a green approach in national policies (renewable energy, energy efficiency of buildings, technologies and processes

with low GHG emissions), the promotion of environmental footprint and the development of banking services and green investment." (Dogaru, 2021: page 4).

There is a study of Lavrinenko et al. (2019) about the role of green economics in sustainable development, namely in the EU member states, that analyses the relationship between them, using the Quintuple Helix model, to explain the impacts of each component of the concept of sustainable development in practice. Their results suggest that there is a positive impact of Green Economy in the sustainable development of the EU countries (Lavrinenko et al., 2019).

2.3 | European Goals for 2050 and the Portuguese case

The UN 2030 agenda for Sustainable Development was created and adopted by its members in 2015 and aims at providing a "shared blueprint for peace and prosperity". The 17 goals drawn are seen as the call-to-action for countries to accomplish a change in their policies and systems, concerning their dimensions and the tackle of climate change (UN, 2015).

According to this agenda, there are several goals that are inevitable to address regarding EVs. The 7th goal – Affordable and Clean Energy – recall ensuring access to reliable, renewable, affordable and modern energy for all. On the other side, the 11th goal of Sustainable Cities and Communities is also related to this matter, as there is the need to transform cities and human settlements in a sustainable way. Moreover, the 13th goal – Climate Action – is directly in line with this topic. There is an urgent need to take action to fight climate change and its effects.

The Paris Agreement and the European Green Deal have been discussed and worked upon in the last years. In 2019, the European Council brought up the objective of, accomplishing the Paris Agreement, making EU climate-neutral by 2050, meaning that Europe intends to have net-zero GHG emissions by this year.

To achieve this, the EC (2021) asked all the state-members to build their own national long-term strategy, consistent with all the previous work. With a time perspective of, at least, thirty years, these strategies need to cover some essential points to fight climate change and become "greener". Firstly, it must be ensured there are "total greenhouse gas emission reductions and enhancements of removals by sinks". Secondly, it must be considered the emissions decreasing and the improvement of eradications in several activity sectors, like industry, the heating and cooling and buildings sector (residential and tertiary), electricity and transport. Besides, members should also give importance to agriculture, waste and land use, land-use change and forestry. Thirdly, countries need to contemplate the expected advances on transition to a low GHG emission (green) economy, including related estimates of long-term

investment, GHG intensity, CO_2 intensity of gross domestic product (GDP), and "strategies for related research, development and innovation". It must also be considered the expected socio-economic impact of decarbonization policies, regarding macroeconomics and social development aspects, as well as environmental protection and health benefits and risks. Finally, it must be included a connection to other countries national long-term goals, besides measures, investment, and policies (EC, 2021).

For example, looking into the Portuguese national long-term strategy, the RNC (Roadmap to Carbon Neutrality) 2050 (MATE, 2019) defines eight pillars that explain the way this transition will be done. It is oriented to create a more competitive, circular, resilient and carbon neutral economy, rising wealth, employment, and well-being, while fighting the climate change impacts and investing in the innovation and research and development in the carbon neutrality field, putting education, territory valorization and justice in the center of the strategy. There is a perspective that, by 2050, 100% of the mobility is electric and that, gradually, electricity will be earning its space over fossil fuels like gasoline or diesel, whose prices will achieve a very low level of cost effectiveness. By 2035, EC wants to phase out the production and selling of fossil fueled vehicles, so that the EVs' adoption can be accelerated. In this interval, the goal is that people still go on transitioning from one type to another. To develop this roadmap, Portugal considered and involved different iterative phases that allowed the gathering of contributions from several institutions and national experts in the area.

In this respect, Dogaru (2021) argued that, when building a national Green Economy model, connected to sustainable development and international communities, it is important to make the decision-making process the clearest possible, as well as to involve "stakeholders through access to data and information, so that the creation of an electronic platform for industrial symbiosis could contribute as an example of good practice". In Dogaru (2021) words, a central coordination and an involvement of all public authorities and the private environment, with all the population are necessary in this process.

2.4 | Transports Sector and Electric Vehicles

Bearing in mind all the previous concepts and theories that allow understanding and deepening the sustainable development concern, some sectors have a critical impact on the amount of existing pollution and climate change conditions. According to data retrieved from PORDATA (2022) about the GHG (CO_2) emissions in Europe, in 2020, the Energy Industry and the Transports Sector were responsible for the greatest parts among other activity sectors. In the previous year, 2019, the trend was the same. Hence, as transports require the energy (both renewable and

fossil) from the energy industry, it is possible to confirm that the transports sector is one of the biggest responsible for a large part of the emissions in Europe. As shown in Figure 2.1., it accounted for 721307 thousand CO_2eq of the GHG emissions, alongside with 780981 thousand CO_2eq of the GHG emissions from the Energy sector.

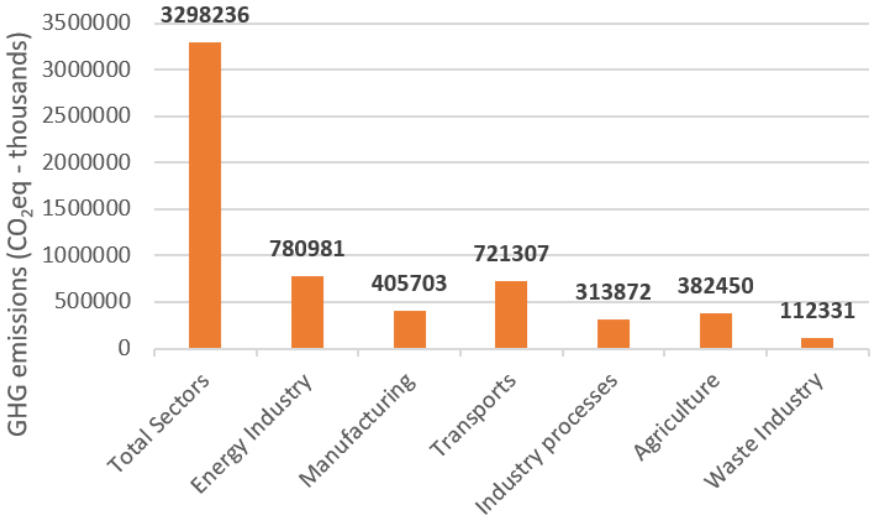


Figure 2.1. | GHG emissions in Europe in 2020, in CO_2eq (thousands), by sector.

Source: PORDATA (2022).

Besides these facts, there are several previous studies like Nunes et al. (2018) that remark the impacts of transports sector on the system, as it is "the prime sector contributing for greenhouse gases (GHGs) emissions in the EU, accountable for 27% of the total emissions in 2016", according to EEA (2017). To achieve the energy transition, there is a need to have on-point transport policies in each country, as they play a major role to society and to the economy, considering that the transport pollution, namely from urban road, is considered the greatest environmental health risk in the EU. Grazi and van den Bergh (2008) argue that one way to prevent it is to apply "centralized clean transport policies", whose outcomes will always depend "on their effects on the modal split, fuel type adopted, energy efficiency and transport volume". It is important to highlight that the EC data from 2014 brought up that, in Europe, buses and railways use account for 14% of the mobility, while private cars represented 74% of dislocations. In contrast, PORDATA (2022) data confirms that, in 2020, only 12.8% of the passengers were transported by buses and railways, whereas, still in 2019, there were a total of 553.5 passenger vehicles per thousand inhabitants, meaning that more than 1 in 2 individuals owned a vehicle. Generally, there are policies to overcome these trends, namely stimulating public transports awareness and usage, reducing the dislocations by private means, as well as spreading the concept of electric mobility, since EVs have a much smaller impact on urban air quality and

climate change than Conventional Vehicles (CVs). Nunes et al. (2018) confirmed this statement and pointed out that the "largest CO_2 emissions reductions (26%) are related to the application of policies promoting the deployment of electric vehicles", advocating that it is, effectively, a fundamental measure to lower these emissions.

2.4.1 | Electric Vehicles

The concept "Electric Vehicles" was first approached, according to Guarnieri (2012), quoted by Vrösch (2018), in 1827, by Ányos Jedlik, who built and drove the first EV of the history. This type of vehicle has been gaining importance and relevance in the last years, due to the climate change and increasing need for consciousness about sustainable development in countries' economies. In 2005, Bansal claimed that an EV "is a vehicle powered by an electric motor, instead of an internal combustion engine (ICE), and the motor is run using the power stored in the batteries.". Over the time, these have emerged, among all the alternatives, as the best option, combining various technologies, with the several types of EVs (Verma et al., 2021).

In the same line as Verma et al. (2021), Sanguesa et al. (2021), depict five types of EVs, regarding the type of their engines technology: Battery Electric Vehicles (BEVs), Plug-in Hybrid Electric Vehicles (PHEVs), Hybrid Electric Vehicles (HEVs) (these last two are often perceived as Hybrid Vehicles), Fuel Cell Electric Vehicles (FCEVs) and, lastly, Extended-Range Electric Vehicles (ER-EVs), as shown in the Annex A, Figure A.2. and Table A.1.

Poyyamani et al. (2021), in the same line, have also studied the EVs and categorized them as Sanguesa et al. (2021), except for the Extended-Range Electric Vehicles, which they didn't consider as a category (see Annex A, Figure A.3.). Indeed, as these authors found out, every type of EVs has a positive impact on the environment, being, consequently, crucial for the energy transition, as they eliminate the negative impacts, namely the emission of GHG into the atmosphere, that CVs demonstrate to have. With their use and the change in the population's behavior, there will be a significant improvement in several dimensions, but certainly in reducing pollution and strengthening the use of renewable energy, besides proving they are clean energy transportation with a high reliability and a compact design structure with a well-equipped control system.

However, there are some challenges that both the authors refer to, regarding these vehicles. Poyyamani et al. (2021) highlight the need for intensifying the research and development of the batteries' technology, since they are a critical part in this topic, besides affirming that the charging infrastructure is also a very important factor, as its development will have an impact on the EVs adoption, accelerating its success and an outstanding worldwide

deployment. In turn, Sanguesa et al. (2021) agree with the challenges of the batteries, arguing that there is still work to be done with respect to the batteries' durability, the EVs charging densities, as well as in the discharging process. These authors go further and refer to some opportunities for a stronger growing, namely the "use of vehicular communications and Artificial Intelligence (AI)", which "can catalyze the actual implementation of the new more ecological and sustainable transport." (Sanguesa et al., 2021: page 396). On the other hand, they point out another great challenge and, at the same time, worry that must be a priority of development for eco-charge and sustainability regarding EVs. More than the daily usage of EVs, it is vital to consider their manufacturing process, as well as the utilization throughout their lifetime, and their disposal and recycling process (Sanguesa et al., 2021), as these are factors that will contribute for the population acceptance and possible purchasing of an EV.

Nevertheless, it is unavoidable to highlight their most valued characteristics, such as the zero tail pipe emissions, the higher powertrain efficiency, the low maintenance required and, the one that makes them one of the best choices, the less urban air pollution and less GHG emissions, with a potential saving of around 90% (Verma et al., 2021). This improves life quality and promotes the ecosystems, considering this type of vehicles are also moved by renewable energy, promoting the controlled use of resources. Bansal (2005) argued that these vehicles are much more eco-friendly than fossil fueled vehicles. Besides, they don't produce the pollution vehicles with an ICE do, because there is no fuel burnt, due to their internal functioning ("electrical energy is stored in a storage battery or ultracapacitor, converted from chemical energy in a fuel cell, or converted from mechanical energy in a flywheel. This electrical energy is used to power an electric motor, which then turns the wheels and provides propulsion") (Bansal, 2005: page 55).

However, Magueta et al. (2017) underline the biggest drawback – they remain considerably more expensive to buy than a fossil fueled car. Although most EU states have offered policy measures, due to the cost, EVs' sales remain imperceptible and, effectively, this cost is often mentioned by consumers as a great negative point when buying an electric. Yet, Bansal (2005) point out that the urban air quality concerns together with increasing consciousness and awareness regarding oil resources and its possible end brought up a rising interest in these vehicles.

According to Sanguesa et al. (2021), EVs present the following advantages comparing to CVs:

- Zero emissions: the vehicle itself doesn't produce tailpipe pollutants, neither carbon dioxide, nor nitrogen dioxide. However, considering the battery production in the vehicles'

manufacturing process, this has a negative impact on carbon footprint, as there is the need for extracting minerals and materials for the batteries;

- Simplicity: the maintenance is very much cheaper, due to the smaller amount of engine elements. Considering they are simpler and more compact, there is no need to exist a cooling system, as well as it is not necessary to "incorporate gearshift, clutch or elements to reduce the engine" noises;
- Reliability: less with less equals more. Since components are simpler, we don't usually see these vehicles breaking down. Additionally, the owner doesn't need to worry about wear and tear produced by engine explosions, vibrations, or fuel corrosion;
- Cost: when comparing EVs to conventional vehicles, currently, the maintenance and "fuel" costs are much lower. Furthermore, Sanguesa et al. (2021: page 373) show that "energy cost per kilometer is significantly lower" in electrics. Nevertheless, the purchasing price of an EV is yet seen as a drawback in the literature;
- Comfort: there is an absence of any engine noise or vibrations caused by the engine. Hence, the driver experience is much more comfortable. Nonetheless, to overcome the imminent danger of not being heard on the road, there are EVs that produce a noise on purpose;
- Efficiency: the authors argue that EVs are more efficient than conventional ones. Nevertheless, they also confirm that "the overall wheel to wheel (WTW) efficiency will also depend on the power plant efficiency. For instance, total WTW efficiency of gasoline vehicles ranges from 11% to 27%, whereas diesel vehicles range from 25% to 37%. In contrast, EVs fed by a natural gas power plant show a WTW efficiency that ranges from 13% to 31%, whereas EVs fed by renewable energy show an overall efficiency up to 70%." (Sanguesa et al., 2021: page 373);
- Accessibility: nowadays, namely in big cities, there exist the so-called low emissions zones. EVs don't have restrictions to these, as they don't achieve high levels of contamination per ride, allowing for their access to urban areas.

The authors also remark the current challenges and disadvantages EVs do face, which are related to batteries. First, "the main drawback" pointed out by the authors is the limited driving range, which is usually between 200 to 350 km, having a full charge, though it is being continuously improved. Then, the charging time is still an issue. To get a full charged battery, it takes 4 to 8 hours, in most of vehicles' models. In the third place, batteries are expensive and, besides that, they are large and heavy, occupying lots of vehicle space.

Even though these vehicles are gaining value and acknowledgement worldwide, while globally growing at a fast rate, they still need to face some challenges in their development, not

only about their production processes and life-cycle assessment (Verma et al., 2021), but also concerning their implementation viability in few years, as previously referred.

2.5 | Electric Vehicles importance in Energy Transition

Energy plays a critical role regarding the climate change mitigation policies. Therefore, it is important to define what the energy transition is. Mitrova and Melkinov (2019) define it as "the series of similar fundamental structural transformations of the global energy sector". The authors denote the need to build the transition on three fundamental pillars - decarbonization, decentralization, and digitization. They also highlight several critical drivers, such as: the technological progress and new solutions building to boost energy sector efficiency, breaking its traditional *modus operandi*; the greater commitment to augment energy security; the countries' goal to turn their economies more attractive and competitive, regarding affordable energy; and the climate agenda.

Gil-García et al. (2021: page 1), on the other hand, argue that "Renewable Energy Sources (RES) and energy efficiency strategies are the core elements of the energy transition", considering the central goal is to drastically decrease the GHG emissions, which will inherently bring down the global warming impacts. The authors also point out that cities have become key elements for the facilitation of policies related to sustainable development, climate action and energy transition, as there is an expressive concentration of population, with economic activity in all sectors and a greater dependence on the transports sector. This sector, as pointed out by the EEA (2017) and PORDATA (2022), is one of the most polluting sectors in Europe. In line with this thought, Poyyamani et al. (2021: page 1) affirm that "the major pollution to the environment is caused mainly by greenhouse gases (GHG) that are emitted by the automobile sector". Not different from the previous studies, Gil-García et al. (2021) argue this sector is responsible for more than 20% of global GHG emissions, as there is a higher use of fossil fuels and a greater level of pollution.

Hence, EVs are seen as the solution for reducing oil consumption and stopping the toxic gases emissions into the atmosphere, since they do not have an internal combustion engine (ICE) (Poyyamani et al., 2021). Thereby, as EVs' fleet replaces the traditional existing one, it is intended to promote the sector's electrification and address for a bigger demand for a renewable energy cycle of utilization (Gil-García et al., 2021). Given the EVs' alternative modes of fueling (electricity, hydrogen, etc.) (Sanguesa et al., 2021), and considering the SDGs and the European Goals for 2050, fossil fuels usage may be decreased, leading to decarbonization and RES cyclical promotion wide utilization. Effectively, the adoption of EVs is expected to enable

the energy transition, not only because they offer a better performance regarding pollution, but also because they promote the RES's development and the correspondent charging infrastructures for EVs users, emphasizing the urge to switch from fossil fuel sources to RES.

2.6 | Electric Vehicles acceptance in Portugal

Understanding the EVs' taxonomy and what they can bring as advantage to the current climate situation and how they can contribute to complete the energy transition with success is fundamental. But it is also important to perceive its acceptance by the populations. Several authors investigated the factors that are a must for increasing this acceptance and inherent purchase intention.

Zhao et al. (2022) conducted a study regarding the city of Shangai, in China, where the authors wanted to understand what determines consumers' acceptance of EVs. The authors found out that consumer's demographic characteristics do influence their purchase intention, being the younger, with a higher income and high education, the ones with more intention to adopt, while big families with less income tend not to be convinced by EVs. On the other hand, "external factors related to EVs such as battery capacity, charging facilities, and restriction policies are highly valued." (Zhao et al., 2022: page 13). Furthermore, there is another factor contributing for this acceptance, the peer effects, as non-EVs drivers will ask their peers, who bought an EV, for advice. Consequently, these effects are considered to be more direct and trustworthy than advertisings and marketing on the vehicles.

In another investigation, but with respect to India, Krishnan and Koshy (2021) concluded that the perceived benefit for the consumers is the key factor and predictor, when purchasing. In addition, "better performance of EVs in terms of speed and power, supplemented by better marketing, distribution and after-sales service can enhance its purchasing intention.". The authors also proved that EVs prices, social influence and technological consciousness have a crucial role on deciding whether to buy an EV or not. This study highlighted some barriers as the possible lack of charging infrastructure, the long recharging time and the limited driving range. However, environmental friendliness is seen as a big advantage.

Vrösch (2018), in accordance with Liao, Molin, & van Wee (2016), argued that there are some barriers for EVs adoption, which can also be seen as key factors for the purchase intention. The vehicles' prices are seen as the major cost barriers. The author holds the idea defended by Krishnan et al. (2021), considering that driving range and its charging duration are still seen as drawbacks.

Vrösch (2018) also emphasized that the consumer awareness and experience with EVs are two key factors for EVs acceptance and deployment. In his study, the author concluded that, in 2018, EVs were not totally accepted by the Lisbon population, identifying the lack of consumer awareness, namely regarding their range and costs, as the potential motive for that fact. However, recalling on the recent fourth edition of the EIB survey (2022) about climate, the evidence shows that Portugal is the leader among the EU, with an EVs purchasing intention 17 p.p above the European average. 84% of the population demonstrates their preference and intention for EVs on the next purchasing. Additionally, in 2022, the Portuguese Ministério do Ambiente e Ação Climática (MAAC) launched the law order no. 3419-B/2022, of March 22, which approves the regulation for the attribution of incentives to the consumption of zero emission vehicles in 2022. Some incentives are on Annex A, Table A.2., but there is an extensive approach on the law order no. 3419-B/2022, of March 22, which is published online at Diário da República Eletrónico.

As concluded on the EIB survey (2022), there is purchasing intention in the Portuguese population and there are governmental incentives to the EVs adoption in the country. However, looking onto the sales of EVs in the Portuguese market, in the period between January and July 2022, according to ACAP (2022), the total vehicles sales are around 131 thousand units, from which only 10 thousand are BEVs. As Annex A, Figure A.4. shows, although there was a great positive variation regarding BEVs sales and a smooth decrease on total sales (that consider all the vehicles, no matter their engines), it is true that EVs still have a tiny account in the total amount of sales.

In fact, Vrösch (2018) argue that consumer awareness is a barrier to the EVs deployment and, despite the good advances, we are far from the goal proposed to achieve by 2050. Tu and Yang (2019: page 19) support this idea and defend that “consumers often hold conservative attitudes toward innovative products due to the lack of the relevant knowledge source”, this is, they will not buy anything until their uncertainties are eradicated. So, gathering both sales data and literature, they suggest that the Portuguese population is not completely aware of or has not enough knowledge of EVs, since although they have a purchase intention, that intention isn’t reflected on increased sales, which can be justified by still some existing barriers, as the EVs prices or batteries related matters and correspondent charging infrastructures. Summarized barriers, determinants and advantages are presented in Annex A, Table A.3.

3 | Data and Methodology

3.1 | Overview

An intensive literature review was performed to highlight relevant points about the EVs thematic, namely concerning what they are and how they can be a differentiator on the energy transition the world is living. In this chapter, we will present the data we have retrieved, the data collection instrument and, afterwards, we will describe the methodology applied in this study.

3.2 | Study purpose & questions

There are several studies, like Tu et al. (2019) in China, that emphasize the consumer awareness as one of the consumer key factors for EVs purchasing, since consumers, who have doubts about how a product can improve their lives, generally, will not purchase the good because they have a lack of awareness and knowledge on it. In the same line of thought, Krishnan et al. (2021), focusing on India, pointed out some factors that have an impact on the purchase intention regarding EVs. As seen before, the authors assert that perceived benefit for the consumers is the key predictor. Vrösch (2018) studied the consumer acceptance of EVs in Lisbon and referred to the consumer awareness as one determinant and barrier at the same time to the purchase. Considering the data retrieved from ACAP (2022) analysis and comparing to Portugal's position in Europe as the country with more EVs purchase intention, it is important to understand the current real consumer awareness in Portugal, as much of the acceptance typically comes from the awareness and we are not observing quite acceptance in real sales numbers.

Hence, given the importance the adoption of EVs has on energy transition and the climate change mitigation, as well as in the European and Portuguese frameworks for the next thirty years, studying what is the real Portuguese EVs awareness, as the leading country in EU concerning purchase intention, can prove to be a benefit for both the government and the scientific community. Following this idea, the present study aims at answering the three already mentioned investigation questions:

a) To what extent are the Portuguese conscious about EVs?
b) Are the EVs perceived as critical for the energy transition, by the Portuguese population?
c) Is there a sense of inner change in the Portuguese population, regarding EVs adoption in the context of energy transition?

3.3 | Method used for data collection

3.3.1 | Instrument

Choosing an empirical method to collect data in an investigation must always be based on previous studies and works. Hence, the literature review elaborated about several studies regarding EVs and the populations' awareness and purchase intention and acceptation gave a perspective of the strategies that have been adopted on this matter.

Considering this analysis, we understood that there is a wide range of articles focusing on EVs' acceptation and purchase intention, like Zhao et al. (2022), Krishnan et al. (2021) or Tu et al. (2019), but too few of them highlight people awareness regarding EVs, for example, Long et al. (2019) pointed out that the Canada population still had doubts about EVs and compared the Canadian consumer awareness between 2013 and 2017. Previously, Zhang et al. (2011) analyzed China's public awareness and acceptance of alternative fuel vehicles, focusing on EVs. Besides these works, there were not found other studies about awareness.

This work is focused into the Portuguese case, where the last investigation about awareness and the consumers' acceptance of EVs in Lisbon was conducted by Vrösch (2018), who highlighted the awareness as a barrier to the EVs adoption.

Bearing in mind the most used instrument in the studied articles and given the limitations considering Portugal as a whole, alongside with the need to collect a great amount of information, we have chosen to perform a survey[1], aiming at obtaining the most recent and accurate data about the Portuguese population, contributing to increase the added value into EVs investigation area. The survey development was based on relevant references such as in published scientific articles (Zhao et al. (2022), Long et al. (2019) and Krause et al. (2013)) and in online surveys in several countries worldwide, emphasizing on the contribution of CarGurus (2021), with a survey about the EV emotion felt, and Goshen Indiana (2021), with an EV awareness survey. Moreover, the remaining literature review allowed helping modeling the questions and possible answers.

For the survey development, we used the Google Forms tool. Two pre-requisites were established for people to be able to answer. First, they must be older than 18 and have a driver's license, so that we could better ascertain their awareness on a subject that, at the inception, only those who are legally qualified to drive will have an interest in. Subsequently, since the study focuses on Portugal, the second pre-requisite was that people had to live on Portuguese territory. The survey was available from August 21, 2022 to September 26, 2022 and it was shared through diverse online social platforms, like Instagram, Facebook and LinkedIn.

[1] The survey available for the respondents is on Annex B (in Portuguese).

Additionally, some participation requests took place by phone and e-mail. It takes an average of about 7 minutes to complete, and the confidentiality of the participants' answers was guaranteed.

3.3.2 | Survey Structure

This survey has also the goal of perceiving the level of knowledge and awareness about EVs on the Portuguese population, regarding their differences, as well as understanding people's opinion and acceptation.

Thus, it is composed of forty-six questions: forty-one closed-ended and five open-ended. Despite being a complicating element in the subsequent part of the data analysis, we concluded that it would be important to have a qualitative perspective on people's perceptions and awareness, with open-ended questions, in order to answer the first research question. The number of questions is organized in four different sections: the first three parts support the data and information collection, so that we can study and draw inferences regarding our three investigation questions; the last one aims at characterizing the collected sample. The sections are presented as it follows.

- Attention to EVs: understand the attention that consumers have to EVs and identify the advantages, disadvantages, determinants and barriers to their acceptance in the perspective of the population, according to those pointed out[2] in the literature by Zhao et al. (2022), Sanguesa et al. (2021), Poyyamani et al. (2021), Verma et al. (2021), Krishnan et al, (2021), Vrösch (2018) and Magueta et al. (2017);
- Knowledge about EVs: divided into two subsections - the first with statements where we measure the respondents' level of agreement with them and which reflects their level of knowledge about the different dimensions of EVs, especially compared to CVs. In the second subsection, we intend to understand the consumers' sensitiveness as well as their acceptance towards the current state of implementation of EVs;
- Awareness of the Impact of Electric Vehicles on Energy Transition: visualize the respondents' position towards the role of EVs in the energy transition, understanding their willingness to change their consumer attitude with respect to sustainable mobility toward EVs. This section will give answers to the first and third investigation questions;
- Sociodemographic characterization: data collection aiming at the demographic characterization of the sample, as well as to understand the frequency of vehicle use,

[2] Available in the Annex A, Table A.3.

which may influence the respondents' perception of the feasibility of EVs' adoption, especially in terms of costs, when compared to CVs.

It is important to emphasize that collecting data from respondents in the different regions of the country was a challenge, so that the sample could be the most representative as possible of Portugal. To overcome this challenge, we sent participation requests by e-mail and through the online platform LinkedIn to potential respondents from regions other than Lisbon and Vale do Tejo, which was being the region where we had, initially, most responses. When we closed the survey on September 26, 2022, 151 valid responses[3] were recorded. Initially, an expectation of 300 validated responses had been considered, so this reflects a success rate of, approximately, 50%.

Investigation Question	Survey section
a) To what extent are the Portuguese conscious about EVs?	(i) Attention to EVs (ii) Knowledge about EVs (iii) Awareness about the impact of electric vehicles on the Energy Transition
b) Are the EVs perceived as critical for the energy transition, by the Portuguese population?	(i) Attention to EVs (ii) Knowledge about EVs
c) Is there a sense of inner change in the Portuguese population, regarding EVs adoption in the context of energy transition?	(i) Attention to EVs (iii) Awareness about the impact of electric vehicles on the Energy Transition

Table 3.1. | Investigation questions and survey sections that aim to answer them.

Source: Author's elaboration.

3.4 | Method used for data analysis

3.4.1 | Data Analysis

After collecting, organizing and processing the survey data, we proceeded to characterize the sample and qualitatively analyze some questions of the survey to answer the first research question. Furthermore, two econometric models were built, in order to assess the relationship between the variables, so as to answer the second and third research questions.

[3] Considering the pre-requisites of the investigation.

It should be noted that a mixed methodology was used, as it is important to understand the general opinion of the sample in this sense, but still quantitatively analyze how important they think EVs are for the energy transition.

3.4.2 | Econometric Models

3.4.2.1 | Definition of Variables

The survey answers allowed to retrieve data for the definition of ten variables: one binary dependent, another ordinal dependent and independent and eight ordinal independent variables[4], which are listed and described in the Table 3.2. below. Two logistic regression (ordinal logit and logit) models were created to help estimating the probability associated with the occurrence of a given change based on the set of independent (explanatory) variables.

Question	Variable name	Answer possibilities
Os VEs são "amigos do ambiente" porque têm zero emissões e a sua utilização mundial reduzirá a poluição do ar, com impactos muito positivos no clima e na Transição Energética.	envfriend	1 (Strongly Disagree) – 6 (Strongly Agree)
De um modo geral, qual o seu nível de interesse pelos VEs?	interest_ev	1 (No interest) – 6 (Extremely Interested)
O desempenho de um VE é similar ao de um veículo convencional.	perform	1 (Strongly Disagree) – 6 (Strongly Agree)
Hoje, é mais fácil carregar os VEs, dado que existem mais estações de carregamento.	charstat	1 (Strongly Disagree) – 6 (Strongly Agree)
É mais fácil ter um VE, porque já há mais possibilidades de o carregar em contexto doméstico.	chardom	1 (Strongly Disagree) – 6 (Strongly Agree)
Os incentivos à aquisição de VEs aumentaram e são mais significativos.”	incstateinc	1 (Strongly Disagree) – 6 (Strongly Agree)
Não há necessidade de pagamento de parquímetro em locais públicos, o que facilita o uso diário dos VEs.”	parkpay	1 (Strongly Disagree) – 6 (Strongly Agree)
Concorda que deveriam existir mais VEs em circulação nas estradas?	evsonroad	1 (Strongly Disagree) – 6 (Strongly Agree)
Estaria disposto a mudar a sua atitude face à mobilidade, para aumentar a utilização de VEs?	change_attit	No Yes
Indique, na escala disponível, o quão forte seria a probabilidade de numa futura aquisição de viatura, vir a optar por um VE.	prob_ev	1 (No Probability) – 6 (Extremely Likely)

Table 3.2. | Description of the variables in the econometric models.

Source: Author’s elaboration.

[4] Ordered variables (ordinal)

These models were built under the assumptions of the following models:

- Ordered Logit Model

$y_i^* = x_i'\beta + u_i$, considering that $y_i = j$ if $\alpha_{j-1} < y_i^* \leq \alpha_j$ (1)

- Logit Model

$y_i = \beta_0 + \beta_1 x_1 + \cdots + \beta_k x_k + u_i,\ y = 1$ if "Yes" ∨ $y = 0$ if "No" (2)

in which "y" represents the ordinal or binary dependent variable and the "x" concerns the ordinal independent variables. "β", in turn, corresponds to the coefficients, which represent the marginal change in the expected value of "y" given a unit change in "x". "u" denotes the stochastic error and measure all the variation in the dependent variable that is not explained by the independent variables, for "k" number of observations.

3.4.2.2 | Definition of Econometric Models

The first econometric model was developed with the purpose of answering the second investigation question. So, its goal is to understand if the EVs are perceived as critical for the energy transition by the sample, considering the sample's opinions regarding three axes – Engines, Acquisition and Cost –, which were also reviewed in the literature, according to Zhao et al. (2022), Sanguesa et al. (2021), Poyyamani et al. (2021), Verma et al. (2021), Krishnan et al, (2021), Vrösch (2018) and Magueta et al. (2017).

Thus, this first model defines the relationship between the dependent variable "envfriend" and the independent variables "interest_ev", "perform", "charstat", "chardom", "incstateinc", "parkpay" and "evsonroad".

Model 1 | Dimensions for the EVs perspective by the sample

$$envfriend = \beta_0 + \beta_1 interest_{ev} + \beta_2 perform + \beta_3 charstat + \beta_4 chardom + \beta_5 incstateinc + \beta_6 parkpay + \beta_7 evsonroad + u_i \quad (3)$$

Then, we developed the second model to find out what is the sample's sense of inner change, with respect to the adoption of EVs in the energy transition context, considering their interest and probability of buying one on their next purchasing, as well as their opinion regarding the environmental advantages of EVs, answering the third research question. Hence, the model defines the relationship between the dependent variable "change_attit" and the independent variables "interest_ev", "prob_ev" and "envfriend".

Model 2 | Sense of inner change in the sample

$$change_{attit} = \beta_0 + \beta_1 interest_{ev} + \beta_2 prob_{ev} + \beta_3 envfriend + u_i \quad (4)$$

3.4.2.3 | Estimation of Econometric Models

According to Wooldridge (2010), the logistic regression model (logit) is a non-linear econometric estimation model, which is used for binary dependent (dummy) variables. This model uses a logarithmic function that restricts the estimated probability values of the dependent variable to the interval {0,1}, making use of a cumulative logistic distribution function. Its objective is to estimate the probability of a given event taking place, based on a certain number of explanatory (independent) variables. The ordered logistic regression model, as a predictive analysis, is an effective approach for cases in which there is an ordinal dependent variable and a set of ordinal or scale independent variables (Centro de Estatística Aplicada, 2022).

The models were estimated using the Maximum Likelihood (ML) method, appropriate for non-linear coefficients, seeking to maximize the likelihood in the parameter estimates. To understand the statistical significance of the coefficients, the Wald's statistical test was also performed, where the following hypothesis were considered:

Hypothesis 0 (H_0): $\beta_k = 0$

Hypothesis 1 (H_A): $\beta_k \neq 0$

Thus, the null hypothesis (H_0) is rejected if the *p-value* is lower than the confidence level of 5%, concluding that the independent variable is statistically significant in explaining the dependent variable, and should remain in the model under study. If the *p-value* is higher than the 5%-level of confidence, but lower than 10%-level confidence, we consider the variable moderately statistically significant and reject H_0. If H_0 is not rejected, it is inferred that the independent variable does not explain the dependent variable, because there is no relationship, and it should be removed from the model.

Furthermore, other metrics were analyzed: The percentage of variation explained, using the *pseudo-*R^2, which varies between 0 and 1, considering that the explanatory capacity will be higher the closer the indicator is to 1; The predictive capacity of the model, which will compare the values predicted by the independent variables with the observed values; the Chi-Square test that evaluates the change in the likelihood ratio value, whose proof value must be lower than the 5% significance level; the sign of the relationship of the variables in the model, in order to understand its impact; and the multicollinearity issue, to perceive if there is an exact (or approximately exact) linear relationship between the independent variables.

4 | Empirical Analysis and Discussion

4.1 | Overview

After the methodology defined and the data collected, the results are presented and discussed in this chapter, in order to, in first place, characterize the sample in study and, afterwards, to answer the research questions of this work.

4.2 | Sample Characterization

To characterize the sample, we analyzed seven dimensions questioned in the survey[5], such as: age; residence area; last completed academic degree; occupation; total monthly net income in household; frequency of car use during the week; and the type of vehicle that respondents do possess.

These are factors that may have an influence towards the opinion, awareness and, inherently, the perception of the respondents about the EVs. With this, we will understand the baseline scenario of our data and results.

4.2.1 | Age

As one of the pre-requisites of the survey was that people must have a driver's license, and in Portugal people are only able to have it at the age of 18 or older, all our respondents are adults.

It can be observed from the figure 4.1. that the greatest slice concerns to respondents between 18 and 30 years old (87 respondents/57.6%). People between 31 and 40 years old correspond to a 24.5% of the whole sample (37 persons) and 15 people between 41 and 50 years old out of 151 respondents, which corresponds to 9.9% of the sample. There were registered 10 respondents between 51 and 60 years old (6.6%) and 2 older than 61 years old (1.3%). Hence, almost 60% of our sample is composed by adult respondents under 30 years of age.

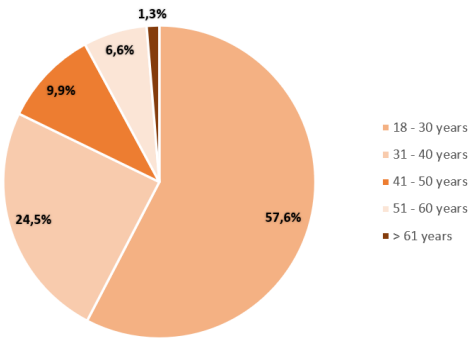


Figure 4.1. | Respondents' age.

Source: Author's elaboration.

[5] Check the results of the answers on the annex C.

4.2.2 | Residence Area

The other precondition to answer the survey was that the respondents should live in Portugal. Thus, it resulted in 151 respondents scattered throughout the different regions of Portugal.

There were 14 persons from the North zone, corresponding to 9.3% of the sample. In turn, 13 respondents live in the Centre zone (8.6%), 7 in Alentejo (4.6%) and 5 in Algarve (3.3%). On the islands, there was a joint percentage of 7.2%, which corresponds to a total of 11 respondents (7 respondents in Azores and 4 respondents in Madeira). As for Lisbon and Vale do Tejo, we verified a percentage of 66.9% that can be observed in figure 4.2., which refers to a total of 101 respondents, thus concluding that most of the sample resides in Lisbon and Vale do Tejo.

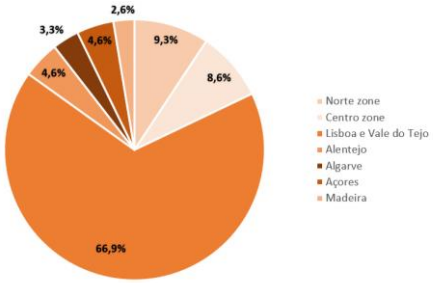


Figure 4.2. | Respondents' residence area.

Source: Author's elaboration.

4.2.3 | Last completed academic degree

Regarding the last completed academic degree, the answer with the highest absolute frequency was BSc, with a total of 72 respondents stating the completion of an undergraduate degree. Immediately followed by MSc, with a total of 51 respondents, corresponding to 33.8% of the sample.

As for secondary/professional education, a total of 20 responses were obtained, corresponding to a percentage of 13.2% of the sample. It was also verified that the degrees with the fewest responses were basic education and PhD. A total of 5 respondents (3.3%) were collected for Basic Education and 3 respondents (2%) for PhD.

We can conclude that around 85% (83.5%) of the sample has completed at least a BSc, in a total of fifteen years of study in Portugal.

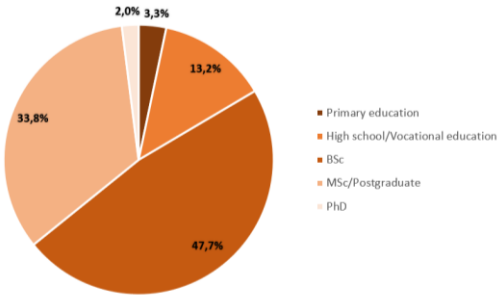


Figure 4.3. | Respondents' last completed academic degree.

Source: Author's elaboration.

4.2.4 | Occupation

As for the occupation of the respondents, we found that there is no retired respondent in the entire sample. Furthermore, there were only 2 unemployed respondents, which corresponds to 1.3% of the sample. We also observed a total of 7.9% of the sample as self-employed and, similarly, a total of 7.9% as working students. The second class with the highest relative frequency recorded was the student class, representing 12.6% of the sample with no job, either dependent work or self-employed.

According to figure 4.4., the majority of the sample (70.2%) are employees, who are dependent on others for their monthly income.

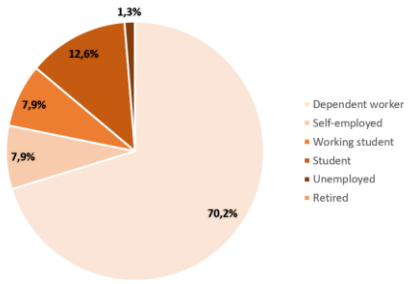


Figure 4.4. | Respondents' occupation.

Source: Author's elaboration.

4.2.5 | Total net monthly household income

Regarding the total net monthly household income, 33.8% of the sample refers to respondents whose household has a net monthly income between 1000€ and 2000€. In turn, 27.8% of the respondents assumed that it is in the range of 2000€ to 3500€, while only 15.2% responded that they have a monthly household income of more than 3500€. With respect to the respondents in the range up to 1000€, there was a relative frequency of 13.2% (20 respondents). Almost 10% (9.9%) of the sample preferred not to reveal the level of total net monthly income in their household.

Therefore, there were recorded 116 respondents with a net monthly household income in the range of 1000€ to 3500€ (61.6%).

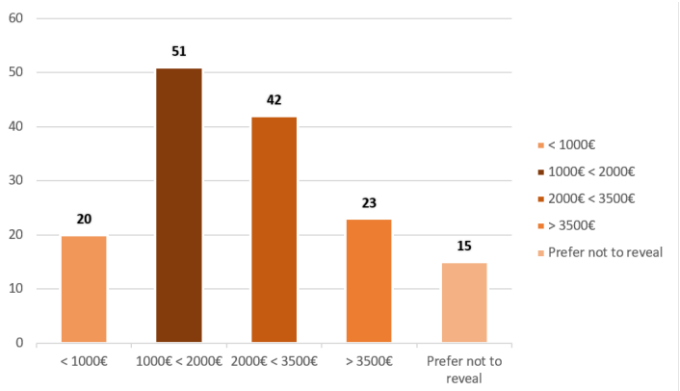


Figure 4.5. | Respondents' total monthly net income in household.

Source: Author's elaboration.

4.2.6 | Frequency of car use during the week

This question is pertinent for the characterization of the sample. Although the previous dimensions have also an impact, the frequency of car use during the week has a direct influence on the respondents' opinion and perception of EVs compared to CVs, since it will have a direct relationship with the refueling costs, with the total emission of GHG into the atmosphere and with the maintenance costs of each vehicle. This influence is portrayed in the sense that respondents who have a lower frequency of car use may not understand the importance of EVs from a cost perspective.

Considering our sample and comparing respondents who use car every day with those who do not use car at all, 25.8% of the respondents stated that they drive every day of the week. Conversely, to a lesser extent (less than half), 10.6% of the respondents indicated that they do not use a car, even though they have a driver's license.

The most expressive answer was "3 to 4 days", with a total of 39 respondents (25.8%). Moreover, 30 people responded they use the car 1 to 2 days a week, corresponding to 19.9% of the sample, and right after that comes "5 to 6 days", whose total answers (27) relate to, practically, 18% (17.9%) of the sample.

Thus, it was verified that there is approximately a percentage of 46% (45.7%) of the sample that uses a car between 1 to 4 days a week. On the other hand, we conclude that the totality of respondents who use a car 5 or more days a week corresponds to, approximately, 44% (43.7%) of the sample. Hence, we observe that more than 40% of the sample uses a car most days of the week.

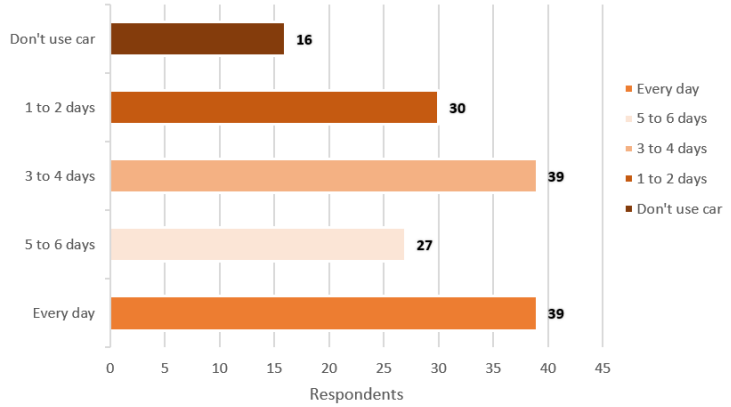


Figure 4.6. | Respondents' frequency of car use during the week.

Source: Author's elaboration.

4.2.7 | Vehicle possession

Understanding whether respondents own some type of vehicle, either an Electric Vehicle (EV) or a Conventional Vehicle (CV), or not at all, becomes important for the characterization of the collected data, as this will impact on the perspective a person has about EVs.

In our sample, it was found that about 62% (61.6%) of the respondents drive a CV, while 32.5% do not own or lease any type of vehicle. It was concluded that 142 respondents, out of a total of 151, do not drive an EV. By contrast, only about 6% of the sample (9 respondents) own an EV, knowing and experiencing in first-hand the driving and inherent dimensions of an EV.

Consequently, it is understandable that the majority of the sample does not currently have a direct contact with the EVs reality, which may impact their opinion and awareness about them, raising doubts and little openness and/or acceptance.

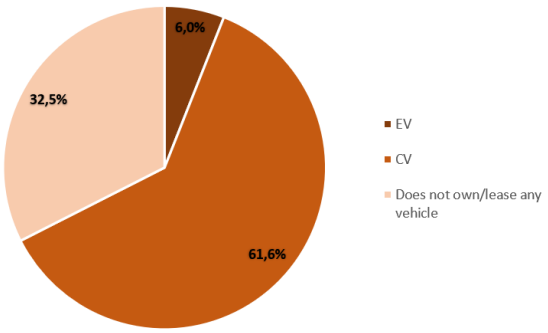


Figure 4.7. | Respondents' vehicles possession.

Source: Author's elaboration.

4.3 | Discussion about research questions

4.3.1 | Overview

In this section, we will draw inferences using the mixed methodology (qualitative and quantitative) we have previously mentioned, in order to get answers to the three research questions of this study.

4.3.2 | To what extent are the Portuguese conscious about EVs?

This question intends to infer about the population's awareness of EVs in society and, in particular, in the energy transition. Thus, using the answers from the survey[6] from each of the sections, inferences will be made.

Firstly, 115 people revealed to be interested in EVs (considering response levels 4, 5 and 6 out of a scale of 6). 21.2% of the sample claimed to be extremely likely (level 6 out of a scale of 6) to purchase an EV at their next purchase. We found about 40% of the sample answering in levels 4 and 5 of the same scale. That is, we can conclude that more than 60% of our respondents consider it very likely that they will acquire an EV in their next purchase.

Furthermore, it is important to understand the answers to the last question of the third section of the survey "Which of the following statements best describes your opinion towards the development of EVs?". This question aims understanding at which level of awareness/acceptance of EVs each respondent would place themselves at. From a 5-nominal level scale, 62 respondents stated to be at level 3, i.e. they think that EVs are an important element in the current context and occasionally follow their development, but have no interest in purchasing one for the time being, since they consider that there are still some barriers compared to CVs, despite their acknowledge about their advantages and benefits. On the other hand, 42 people consider that EVs can have a positive impact on the energy transition, although they are not the key factor. They state that they do not follow the evolution of these vehicles, but acknowledge that the use of CVs is harmful to the environment in some aspects. For instance, 39 of the sample respondents believe that EVs are already our present and that they have a critical role in the energy transition, since the transports sector is one of the most polluting, and, with them, we will be able to use more renewable energies, which will be a crucial milestone in the transition. They follow the evolution of this type of vehicles in detail and already have one/are thinking about buying one in the next purchase. Only 5 respondents stated that they have no idea how the development of EVs is going, because they don't consider them to be an added value for the Portuguese, in the national context. In their opinion, priority should

[6] The results of the answers can be seen on the annex D.

continue to be given to CVs. Nevertheless, we conclude that 101 respondents, which corresponds to 66.9% of the sample, follow the evolution of EVs, recognizing their relevance in the current context of energy transition.

From the previous analysis, a framework (mental map) was built, according to the data collected in the survey, in order to answer the first research question. The aim of the framework (Figure 4.8.) is to explain the relationship between the three "axes" of EVs. If the population does not have full knowledge about the motor axis and the cost axis, the likelihood of purchasing an EV will be low, as there is no full awareness and, therefore, no trust.

Figure 4.8. | EVs Mental Map, according to the study instrument.

Source: Author's elaboration.

Considering the opinion of the sample population regarding some dimensions of the EVs in the survey, it is important to proceed to a more specific analysis, taking into account our framework:

- Engines
  - Concerning the way EV models are fueled (Annex A, Table A.1.), 80.1% of the sample states that an HEV is fueled with both gasoline and electricity, while in fact, according to the literature, this model is fueled only with gasoline (an option that only 12.6% of the sample stated as being correct), despite having, as PHEVs, both an electric engine and an ICE. Hence, it is not clear to the sample the differences concerning HEVs compared to PHEVs. On the other hand, when we refer to a BEV, most of the sample (90.7%) has no doubt that they are only fueled through electricity. Moreover, 48.3% of the sample

showed not knowing or not wanting to answer this question referring to FCEVs, considering that only 31.8% (48 respondents) correctly stated that they are fueled by Hydrogen/Oxygen. Regarding that approximately 70% of the sample does not know the correct way to fuel a FCEV, we conclude that there is little awareness of this type in the sample.

  - Regarding the fact that EVs are quieter than CVs, the respondents showed to have almost no doubts. On a 6-level scale, 94% of the respondents agreed with this fact.
  - However, when it comes to the range of EVs, a more even distribution across 4 levels of the 6 is observed. Only 24 respondents strongly agree that EV technology has matured and has now a much better range. Also, when confronted with the statement "EVs are "environmentally friendly" because they have zero emissions and their worldwide use will reduce air pollution, with very positive impacts on climate and the Energy Transition.", the answers followed the same trend. 31.1% strongly agree with the statement. However, there are still doubts within the remaining sample.

- Costs
  - Regarding the charging costs of an EV, 27.8% of the respondents strongly agree that they are much lower than for a CV. However, it is still not entirely clear to the sample population, as 64.2% of them is split between levels 3 to 5 out of a scale of 6.
  - The same pattern occurs when the respondents are faced with the statement "There is no need to pay a parking meter in public places, which facilitates the daily use of EVs.". 67.6% of the sample agrees with the statement, while the remaining percentage disagrees.
- Acquisition
  - When asked which of the two EV models they know, the most frequent answers given by the sample were "Renault Zoe", "Nissan Leaf", "Tesla Model 3" and "Tesla Model X". On the other hand, the respondents showed to have a notion about the purchase cost of an EV compared to a CV. According to the website "Dinheiro Vivo", the average price of a CV in Portugal in 2022 is 20.000€, however, according to the official websites of Renault, Nissan and Tesla, the prices of the models most cited by respondents range from 27.900€ (Nissan Leaf) to over 145.990€ (Tesla Model X). From the sample, 93.4% answered that an EV costs at least 10% more than a CV, with only 16.6% agreeing that they cost at least 50% more than a CV. We conclude that the sample population is aware of the acquisition costs of EVs.
  - Considering the government intervention through incentives implemented for electric mobility in Portugal, most of the sample (60.9%) neither agrees nor disagrees that these

incentives have increased and are more significant. In fact, through the Portuguese law order no.3419-B/2022, of March 22 (Annex A, Table A.2.), there is a greater comprehensiveness in what concerns the diffusion and implementation of electric mobility in Portugal.

Thus, we conclude that the sample population is moderately aware of EVs. If, on one hand, they are quite knowledgeable about the acquisition costs of a new EV, the truth is that most of the sample is not fully aware of the different dimensions of EVs engines. On the other hand, looking at the costs with an EV, the sample does not acknowledge that refueling is cheaper, nor that there is an easier access to urban centers with an EV, a trend that is noticeably repeated regarding the incentives implemented by the government. As previously mentioned, although Portugal is the EU country with the highest purchase intention, factors like the EVs prices and charging infrastructures are still barriers, though the sample recognizes the advantages of their use for the environment. However, considering that our sample is not fully representative, it does not allow to generalize these results to the Portuguese population.

4.3.3 | Are the EVs perceived as critical for the energy transition, by the Portuguese population?

Understanding the importance that the sample attaches to EVs in the context of the energy transition is essential. Firstly, this perception and recognition is one of the main drivers of the mindset change that will lead to the adoption of EVs and their large-scale implementation. Furthermore, if this does not exist, there is no acceptance, according to Vrösch (2018), so there is no trust in EVs, which will delay adoption and slow down the energy transition, which is currently crucial.

Thus, the second research question seeks to understand whether the population considers EVs as critical for the energy transition to occur, and the variables in question refer to some of the advantages enunciated by the cited authors, e.g. Zhao et al. (2022), Sanguesa et al. (2021), Poyyamani et al. (2021), Verma et al. (2021), Krishnan et al, (2021), Vrösch (2018) and Magueta et al. (2017).

Survey question	Variable name
Os VEs são "amigos do ambiente" porque têm zero emissões e a sua utilização mundial reduzirá a poluição do ar, com impactos muito positivos no clima e na Transição Energética.	envfriend
De um modo geral, qual o seu nível de interesse pelos VEs?	interest_ev
Os incentivos à aquisição de VEs aumentaram e são mais significativos."	incstateinc
Não há necessidade de pagamento de parquímetro em locais públicos, o que facilita o uso diário dos VEs."	parkpay
Concorda que deveriam existir mais VEs em circulação nas estradas?	evsonroad

Table 4.1. | Description of the variables in the econometric model 1.

Source: Author's elaboration.

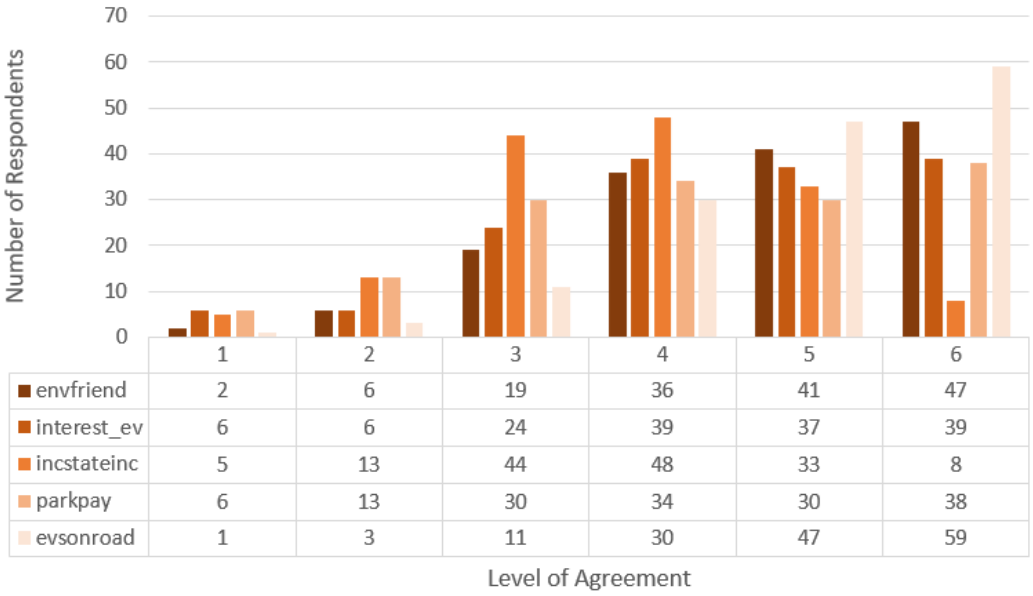
Analyzing figure 4.9.[7] and considering the variables meaning in Table 4.1, it can be observed that there is an increasing trend in the attribution of importance and agreement that EVs are "environmentally friendly", given their zero emissions during circulation, which will have very positive impacts on climate and on the energy transition., About 31% of the sample (47 respondents) strongly agree with this statement. In turn, the same trend is noted regarding the interest of respondents in the EVs, since approximately 76% (76.1%) of the sample is concentrated between levels 4 to 6 of interest, in a 6-level Likert scale.

The trend is different regarding the variable "incstateinc". It is possible to observe that the majority of the sample is fixed on the levels 3 and 4 (about 61%), meaning that 92 respondents do not totally agree nor totally disagree that government incentives regarding EVs had increased and are more powerful. In contrast, only 5% of the sample strongly agrees with, while 3% strongly disagrees, which can be related to the lack of acknowledgement of the Portuguese government laws regarding this matter.

Regarding the variable "parkpay", it can be concluded that the sample tends to recognize the advantage of EVs that is related to the lack of needing to pay taxes that CVs normally pay, parking being one of them. About 67.5% of the respondents agree with this statement, choosing between levels 4 and 6 of the scale available for response.

In the same line as "envfriend" and "interest_ev", it can be seen that "evsonroad" has an upward trend, with 59 respondents (39%) strongly agreeing with having more EVs circulating on roads, apart from 1 respondent who did not agree with this.

[7] To check the results of the answers, please, see annex E.



	1	2	3	4	5	6
envfriend	2	6	19	36	41	47
interest_ev	6	6	24	39	37	39
incstateinc	5	13	44	48	33	8
parkpay	6	13	30	34	30	38
evsonroad	1	3	11	30	47	59

Figure 4.9. | Sample's opinions on EVs.

Source: Author's elaboration.

For model 1[8], where we estimated the dimensions for the EVs perspective by the sample, it was considered independent variables whose base questions are related to the attribution of the importance of the EV as a driver of the energy transition and are therefore assumed to be advantages of EVs. Hence, the initial chosen independent variables were "interest_ev", "perform", "charstat", "chardom", "incstateinc", parkpay" and "evsonroad". The Wald test was applied in order to understand the statistical significance of the variables under study, i.e., to find out the position of their *p-value* in relation to the confidence level (5%). Thus, it was concluded that the variables "perform", "charstat" and "chardom" are not statistically significant, considering their *p-value* higher than the confidence levels of 5% and 10%, and were subsequently removed from the model. The final model was estimated only with the independent variables that have explicative capacity over the dependent variable "envfriend". On table 4.2., it can be observed the model 1 indicators, with the *p-value* for each independent variable considered.

[8] The model details are available on the chapter 3.4.2.2.; the details about the variables' description are available on the Table 4.1.

envfriend	Model 1				
	β	*p-value*	*Pseudo-R^2* (Nagelkerke)	Hosmer and Lemeshow Test	
				Chi-Square	*p-value*
interest_ev	**0.235**	**0.097**	**0.468**	**88.801**	**< 0.001**
incstateinc	**-0.330**	**0.028**			
parkpay	**0.238**	**0.033**			
evsonroad	**1.425**	**< 0.001**			

Table 4.2. | Econometric model 1' indicators (EVs' importance).

Source: Author's elaboration.

The explanatory independent variables that were, thus, considered are "interest_ev", "incstateinc", "parkpay", and "evsonroad". With the exception of "interest_ev" that has a *p-value* higher than the 5%-level of confidence, but lower than the 10%-level of confidence and, therefore, is moderately statistically significant, the remaining ones present a *p-value* under 5%. Hence, the null hypothesis (H_0: βk = 0) of the Wald test is rejected, for which all the four must be included in the model, as they are statistically significant. From these results, we can affirm that as one person shows more interest on EVs, as he/she agrees more strongly with having more of them in the roads and as he/she acknowledge EVs advantage regarding taxes paying, therefore, there is an increased probability of a higher agreement that EVs are "environment friendly" and have great benefits for the pollution reduction and energy transition. Furthermore, we can also conclude that as one person shows more knowledge about the incentives implemented by the government, there is an increased probability of a lower agreement that EVs are advantageous for energy transition.

On the other hand, this model has a *pseudo-R^2* value of 0.468, meaning that almost 50% (46.8%) of the probability of attributing more importance to EVs in the energy transition is explained by the independent variables. Thus, we can conclude the model reflects the probability link between the EVs importance on people's perspective and the considered EVs advantages.

Besides, a multicollinearity test was performed to understand if the independent variables do establish an exact (or approximately exact) linear relationship between them. It was observed that the model does not present a multicollinearity issue, as the tolerance values of each included independent variable are higher than 0.1 and their VIF values are lower than 10.

Consequently, we can conclude that a great part of the respondents perceives EVs as critical for the energy transition, although we do observe that there is still a lack of awareness and knowledge about their dimensions and the way they are critical, as well as the difference

they will have on the EVs implementation in Portugal. Nonetheless, as previously mentioned, our sample isn't representative of the whole Portuguese population, so we are not able to generalize these conclusions.

4.3.4 | Is there a sense of inner change in the Portuguese population, regarding EVs adoption in the context of energy transition?

Understanding how people are willing to participate in this change and adjust their own habits in the context of EVs is important, since it will be the consumer that will be the major driver for the adoption of EVs in Portugal and the consequent acceleration of the energy transition.

Regarding the respondents' willingness to change their attitude towards mobility in order to increase the use of EVs, it can be concluded, from figure 4.10., that 62 respondents out of 151 stated that they are not available for this change which corresponds to a total of 41.1% of the sample. In contrast, approximately 60% (58.9%) present a consciousness of change to leverage the energy transition in Portugal.

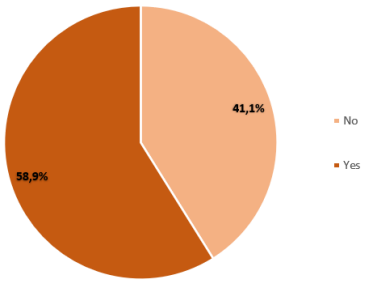


Figure 4.10. | Sample's availability on changing their inner attitude towards mobility.

Source: Author's elaboration.

On the other hand, the data in figure 4.11.[9] allows inferring that a large part of the sample is interested in EVs, since, on a 6-level Likert scale, approximately 76.2% of the respondents focus on levels 4 to 6 (Total interest), leaving only 36 respondents (23.8%) between level 1 (No interest) and level 3, which could be explained by the fact that approximately 92% of the respondents considers that EVs are important for the energy transition (Annex E, Table E.1.). However, when we look at the respondents' likelihood to purchase an EV in a next purchase, a more symmetrical split is seen. Indeed, 32 respondents say they are extremely likely to buy an EV, while 10 have no intention in purchasing one. Between levels 2 and 3 of the available scale to response, there is 31.8% of the sample (48 respondents), while in levels 4 and 5 there are 61 respondents (40.4%).

[9] Check the results of the answers on the annex F.

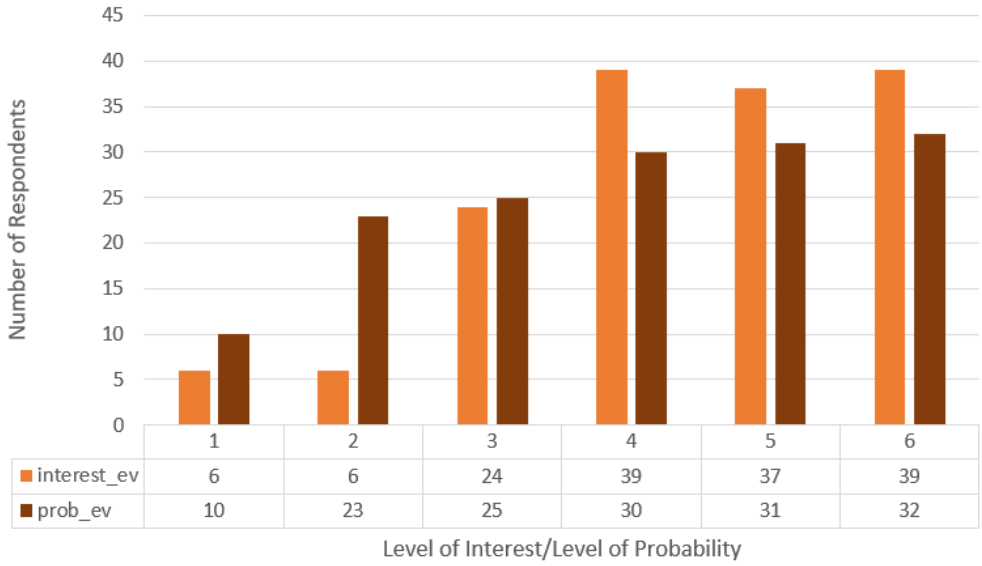


Figure 4.11. | Sample's interest on EVs and purchasing intention on the next acquisition.

Source: Author's elaboration.

Question	Variable name
Estaria disposto a mudar a sua atitude face à mobilidade, para aumentar a utilização de VEs?	change_attit
De um modo geral, qual o seu nível de interesse pelos VEs?	interest_ev
Indique, na escala disponível, o quão forte seria a probabilidade de numa futura aquisição de viatura, vir a optar por um VE.	prob_ev

Table 4.3. | Description of the variables in the econometric model 2.

Source: Author's elaboration.

Model 2[10] (where we estimated the sense of inner change in the sample) was initially estimated with the independent variables "interest_ev", "prob_ev" and "envfriend". However, through econometric analysis, it was verified that the variable "envfriend" is not statistically significant for the model, as the null hypothesis (H_0: βk = 0) of the Wald test was not rejected, considering its *p-value* higher than the 5% confidence level and the 10% confidence level. Thus, this variable was removed from the model, leaving only "interest_ev" and "prob_ev".

According to the table 4.4., the independent variable "interest_ev" presents a *p-value* below the confidence level, being statistically significant for the model, thus rejecting the null hypothesis (H_0: βk = 0) of the Wald test, which allows verifying the existing relationship with the dependent variable. In turn, the *p-value* of the independent variable "prob_ev" is higher than

[10] The model details are available on the chapter 3.4.2.2.; the details about the variables' description are available on the table 4.3.

the 5% confidence level, but lower than the 10% confidence level, so it is considered moderately statistically significant for the model, rejecting the null hypothesis of the Wald test and acknowledging its impact on the dependent variable "change_attit".

change_attit	Model 2					
	p-value	Exp (B) – odds ratio	*Pseudo-R^2* (Nagelkerke)	Correct Model Prediction (%)	Hosmer and Lemeshow Test	
					Chi-Square	*p-value*
interest_ev	**0,011**	**1,674**	**0,253**	**76,2%**	**11,017**	**0,201**
prob_ev	**0,099**	**1,316**				

Table 4.4. | Econometric model 2' indicators (sense of inner change).

Source: Author's elaboration.

From the table 4.4. analysis, we are also able to conclude that as one person shows more interest on EVs and admits having a higher probability of buying one in a next purchase, there is an increase in the probability of changing the inner mindset about EVs and taking the change further, accelerating these vehicles adoption and energy transition.

Considering that the model correctly predicts 76.2% of the dependent variable and that the independent variables are statistically significant for the model, we conclude that the variables "interest_ev" and "prob_ev" contribute to explain the probability that a respondent is willing to change his/her attitude towards EVs in the context of the energy transition. That is, if a person shows interest in EVs and is interested in acquiring one in the next purchase, it means that he/she is available to change his/her attitude and leverage the energy transition, with his/her contribution in the context of mobility. Hence, it can be concluded that there is a sense of inner change in more than 50% of the sample, but the trend is that it increases, as long as people's interest in EVs also increase, as well as the probability of buying an EV. But, as said before, since our sample does not fully represent the entire Portuguese population, we cannot assert this applies to Portugal as a whole.

5 | Conclusion and Considerations

5.1 | Investigation Conclusions

The main objective of this research was to understand if there is a complete level of awareness in the sample population about the role of EV adoption in the energy transition, considering the European objectives for 2050 on the circulation of EVs in Europe. The research analyzed the importance attached to EVs by the respondents, as well as their willingness to change the current panorama, considering EVs' advantages and disadvantages.

In order to answer the research questions of the present study, a survey focused on the Portuguese population, over 18 years old and holders of a driving license, as well as those living in Portugal, was carried out, collecting specific and current data. From 300 expected answers, a total of 151 opinions were obtained, which corresponds to a success rate of approximately 50% in the period considered for data collection.

The processing of the data collected from the sample allowed characterizing the sample in several dimensions, such as age, area of residence, academic background, current employment situation, monthly net income per household, as well as the frequency of car use and the type of vehicle they own. In this sense, it was concluded that 57.6% of the sample is between 18 and 30 years old and that most respondents live in Lisbon and Vale do Tejo (66.9%), although all regions of Portugal are represented in the sample. The majority (approximately 85%) have at least a BSc degree, while 106 respondents (70.2%) are dependent workers. On the other hand, 61.6% of the sample have a net monthly household income between 1000€ and 3500€, with a total of 20 people having less than 1000€ net monthly household income. With regard to car ownership and use, 93 respondents claim to own a CV, while in contrast, only 6% of the sample (9 persons) claim to drive an EV. 45.7% of the respondents use a car 1 to 4 days a week.

The sample revealed to be moderately aware about EVs. According to the framework created for the research, on the one hand, they show knowledge about the acquisition axis, i.e. they acknowledge the existing charges when purchasing a new EV and know the price positioning of these vehicles compared to the average price of a CV, since 93.4% of the sample states that an EV is at least 10% more expensive than a CV. However, they are not fully aware about the different engine dimensions of EVs. For instance, only 12.6% are aware that an HEV is fueled only by gasoline and that electric power is generated from the normal combustion process of fossil fuels (in spite of having, as PHEVs, both an ICE and an electric engine, this last one is not pluggable to the power grid), while 90.7% have no doubt that a BEV is fueled only by electricity. Nevertheless, on the other hand, it was found that there is a practically null

awareness about FCEVs, as approximately 70% of respondents would not know how to fuel them if they had one. Regarding the cost, however, it is not clear to the respondents that the cost of fueling an EV ends up being lower. On a 6-level agreement scale, 64.2% responded in the range between 3 and 5 levels, while only 27.8% strongly agreed with this fact, by choosing the 6 level. In what concerns the recognition of the incentives applied by the government for the adoption of an electric mobility in Portugal, it was noted that 60.9% of the sample neither agrees nor disagrees that these have increased and are more significant.

In fact, only 39 respondents follow the evolution of EVs in detail and are interested in purchasing one already in the next purchase, as they believe it will have positive effects on the energy transition since they use renewable energies. We conclude that 74.2% of the sample still does not have full confidence in EVs, which can be explained by the lack of existing awareness on the topic.

However, overall, the sample tends to perceive EVs as critical for the energy transition in Portugal, with 92.1% of the sample recognizing their importance. 82.1% of the respondents (who chose levels comprised between 4 and 6 of the 6-level agreement scale) tend to agree that EVs are environmentally friendly and that their use will have positive impacts on climate and energy transition. Subsequently, for this opinion, awareness on other dimensions such as government incentives, park tax exemption, as well as agreement with more EVs in circulation and people's interest in EVs were found to have a relevant impact on explaining it. However, it was found that there is a lack of awareness about the specific way in which EVs might be determinant.

Concerning the feeling and willingness to adopt EVs in the context of the energy transition, it was concluded that this exists in approximately 59% (58.9%) of the sample, considering that the trend increases, while at the same time the interest in EVs by the respondents and the likelihood of acquiring one also increases, as it was found that these two variables have a positive impact on the perception and willingness to change in the sample.

The major inference to be drawn from this study is connected with the fact that awareness about EVs is critical in the context of energy transition, since it stands out as the catalyst of the perception of importance attached to these vehicles by the population and, at the same time, the facilitator of the feeling of inner change in people who, along with the current governmental efforts and incentives, will be more prone to make the shift from CVs to EVs. Thus, it may be important to continue the work of making the access to EVs easier, not only by impacting prices, but also with actions to improve the purchasing power of the population and to raise awareness about the importance of each citizen's contribution to the energy transition. Nevertheless, it is essential to remark that this study sample is not fully representative of all the

regions of Portugal, as the majority of the respondents live in Lisbon and Vale do Tejo (66.9%), so it does not allow any generalization to the Portuguese population.

Furthermore, and given the current international panorama, it is of great importance to mention the consequences of the Russia-Ukraine armed conflict in Europe, in the global economy as a whole and at the level of the energy sector. As can be observed, the conflict has had a profound impact on the prices of fossil fuels, electricity and natural gas, as it brings increased volatility in the markets and global uncertainty. Therefore, although the repercussions of the conflict on international policies to fight climate change have not yet been identified, the truth is that it could be a catalyst for the energy transition, since a faster development of renewable energy can be expected, through global investment for each country to be self-sufficient in this regard and not be as dependent as is currently the case.

5.2 | Study Limitations

The research carried out brought some challenges and inevitably has some limitations. The first challenge encountered was found in the literature review. Since the topic under study is related to awareness about EVs in Portugal, our research focused on this field. However, we quickly realized that there are very few literature materials deepening specifically the awareness topic. There are more studies about the acceptance of EVs, with awareness being a determinant of this acceptance. From this arose the second challenge of obtaining data on awareness to use in the research. Indeed, there is almost no data, so we chose to use the survey for recent and specific data on the subject in Portugal.

Secondly, there is a limitation in the number of responses, which proved to be low. Initially, we intended a sample of at least 300 respondents, but we reached 151 responses, with a success rate of approximately 50%. Considering that the goal was for the sample to be representative of all regions in Portugal, the truth is that approximately 67% of the sample is from Lisbon and Vale do Tejo, while the remaining regions do not exceed 10%. Thus, another limitation of the study lies in the fact that the sample is not fully representative and, therefore, does not allow any type of generalization of results to Portugal as a whole.

Due to the reduced dimension of the sample, there was another limitation at the level of analysis of the econometric models developed, since not all independent variables have enough explanatory capacity on the dependent variables under study.

5.3 | Future Recommendations in Research

During this work, new insights for future research in the area emerged. One recommendation to keep in mind when re-studying this topic is the working instrument. If the choice falls on a survey, it should be focused only on the dimension of consumer awareness, with possibilities for more quantitative answers, for a more robust quantitative analysis.

On the other hand, and due to the major limitation of this study, it is important to have a larger sample of data in the research, with a broader scope, if the objective is to have a national perspective of the thematic. For this, it is suggested that an incisive strategy is adopted in the different regions of the country, using the help of public organizations/institutions, which will have contact with a large part of the population, appealing to the importance of their help in collecting people's opinions.

From another perspective, it might also be interesting to conduct more detailed analysis taking into account the socio-demographic characteristics of the respondents. For instance, understanding which region of Portugal has more awareness of EVs or understanding whether the age has an impact on this awareness. In sequence, understanding also whether different types of education or different types of contractual and salary conditions have an impact on consumer perception of the importance of EVs for the energy transition may prove to be important for a better insight into the reasons justifying the current state of EV awareness and adoption in Portugal.

Furthermore, we suggest investigating what are the key determinants of the interest in EVs, which lead to people’s awareness and perception of importance, through a massive data collection in Portugal, which will also allow a more accurate work in accelerating the deployment of EVs in the country.

In order to promote a more conscious decision making by political agents, it might be interesting to understand which dimensions, factors or determinants make consumers consider a change of attitude towards electric mobility, not only at an economic level, taking, for example, market issues with the price of EVs, which is pointed out as the greatest barrier to the adoption of EVs in Portugal in our study, but also at the labor level, with wage issues (which may be directly related), in order to understand where one can and should focus to improve the current panorama and facilitate the population's switching from CVs to EVs in the medium/long-run.

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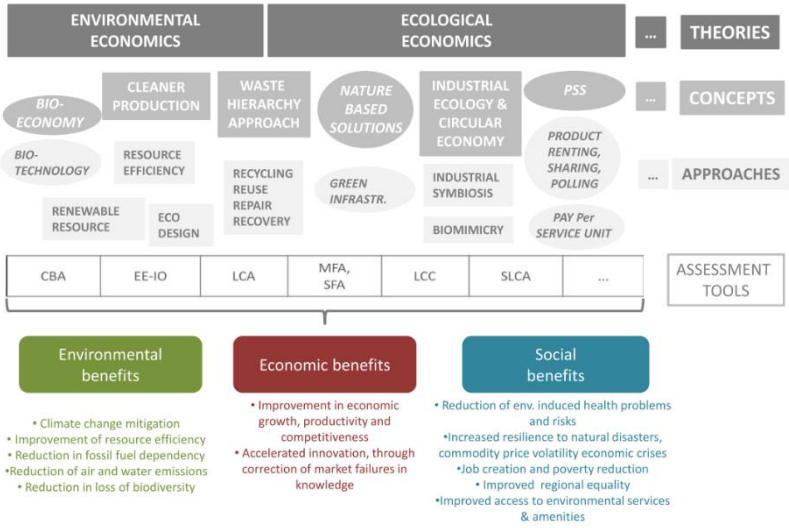
Annexes

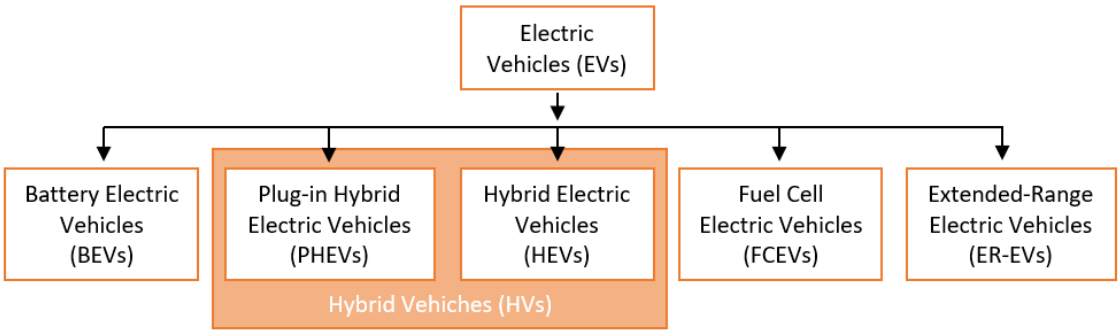
Annex A | Literature Review

Figure A.1. | Generic framework showing the different layers of the Green Economy.



Source: Loiseau et al. (2016).

Figure A.2. | EVs categorization.



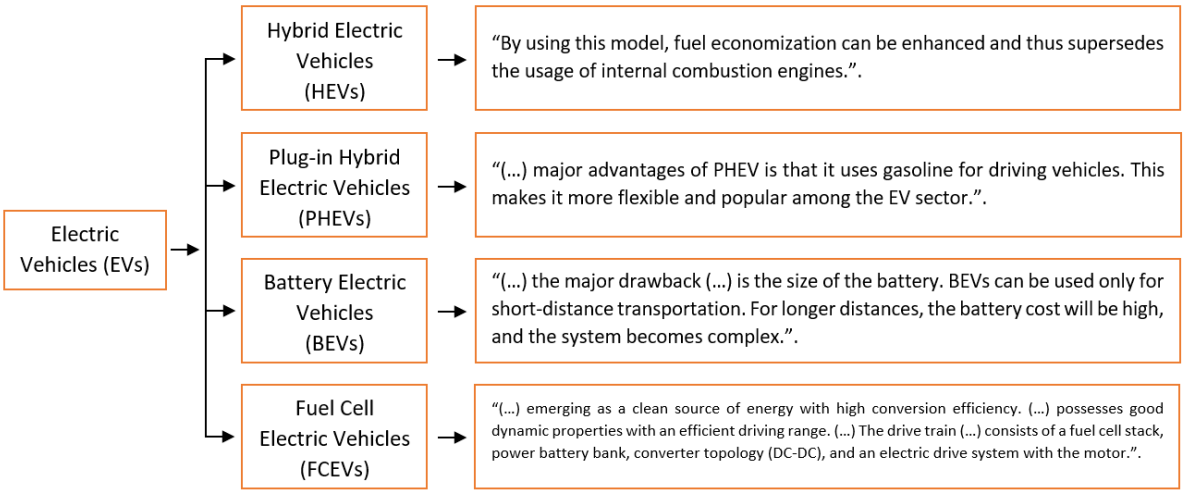
Source: Sanguesa et al. (2021).

Table A.1. | EVs characterization.

Type of EV		Characteristics	Example
Battery Electric Vehicles (BEVs)		These vehicles are fully moved by electric energy and power, as they neither carry an internal combustion engine (ICE), nor require the usage of any liquid fuel. This type of vehicle is characterized by having "large packs of batteries", so that the vehicle has a good and acceptable autonomy for daily utilization.	Nissan Leaf
Hybrid Vehicles (HVs)	Plug-In Hybrid Electric Vehicles (PHEVs)	Vehicles that have a traditional ICE and an electric engine, which is charged by a pluggable to the power grid. Their intent is to be able to store enough electricity from the grid, in order to substantially reduce their fuel consumption on the ICE, "in regular driving conditions".	Mitsubishi Outlander
	Hybrid Electric Vehicles (HEVs)	Vehicles that have a traditional ICE and an electric engine. However, this electric engine is not pluggable to an external electric source. The intent is that the battery of the electric engine can be charged by the power generated by the ICE, both during the driving and, more recently, during braking, "turning kinetic energy into electric energy".	Toyota Prius (4th generation)
Fuel Cell Electric Vehicles (FCEVs)		They are moved by an electric engine, which utilizes a "mix of compressed hydrogen and oxygen obtained from the air", with water as the only waste resulting from this. The authors affirm that, regardless the zero emissions resulted from this vehicle type, most of the 'fueling' hydrogen comes from natural gas, despite the existence of green hydrogen.	Hyundai Nexo
Extended-Range Electric Vehicles (ER-EVs)		Despite the existing similarities with BEVs, these vehicles also carry a "supplementary combustion engine, which charges the batteries of the vehicle if needed.". This engine has only one purpose: charging the electric battery, so it is not connected to the wheels, unlike those in PHEVs and HEVs.	BMW i3

Source: Sanguesa et al. (2021).

Figure A.3. | EVs categorization and characterization.



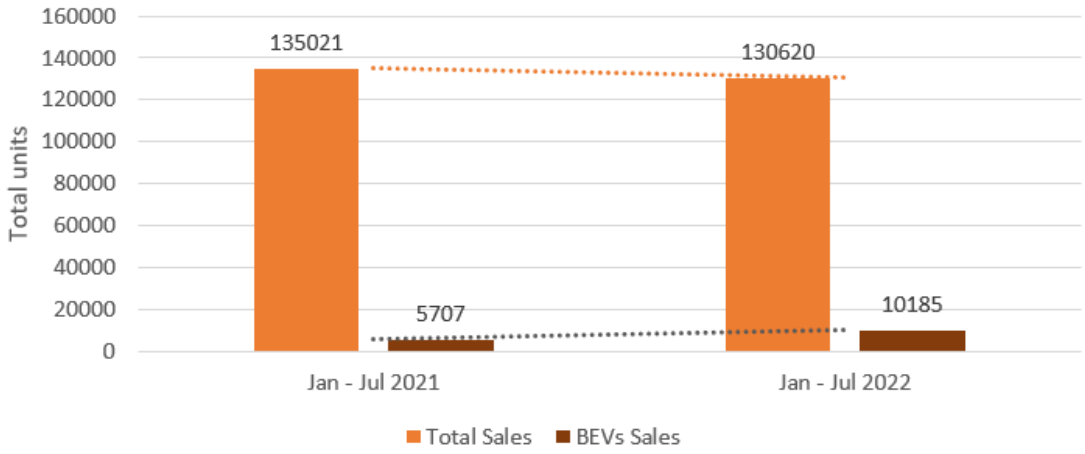
Source: Poyyamani et al. (2021).

Table A.2. | Portuguese government 2022 incentives for the adoption of EVs, translated from the original document by the author.

Portuguese law order no.3419-B/2022, of March 22	"(…) installation of **private charging stations** in condominiums, with a global allocation of **10M euros**."
	"The incentive for the introduction in consumption of zero emission light **passenger vehicles** is translated as the attribution of an incentive in the value of 4000 (euro) **(four thousand euros) for individuals**, and is due for the introduction in consumption of a new 100% electric vehicle."
	"The incentive for the introduction into consumption of zero emission light goods vehicles is translated in the form of the attribution of an incentive in the value of 6000 (euro) **(six thousand euros)** and is due for the introduction into consumption of a new 100% electric vehicle."
	"The incentive for the introduction into consumption of **motorcycles, mopeds, tricycles, quadricycles and personal mobility devices, electric**, is translated into the attribution of an incentive in the value of **50% of the acquisition value of the vehicle or device, including VAT, up to a maximum of 500 (euro) (five hundred euros)**, due for the introduction into consumption of any of them, new, whose first acquisition and registration, if applicable, was made in the applicant's name after January 1st, 2022."
	"(…) **chargers for electric vehicles in multi-family condominiums** with connection to the Mobi.E Network (…) The incentive related to chargers for electric vehicles is expressed in the form of granting an **incentive amounting to 80% of the purchase price of the charger, including VAT, up to a maximum of 800 (euro) (eight hundred euros) per charger**, one charger corresponding to one parking space, to which may be added 80% of the value of the electrical installation associated with the charger purchased (including VAT), up to a maximum of 1000 (euro) (one thousand euros) per parking space."
	"The incentive's attribution covers the **entire national territory**."

Source: Portuguese law order no.3419-B/2022, of March 22.

Figure A.4. | Total Sales vs. BEVs Sales in Portugal, comparing the first semester of the year in 2021 and 2022.



Source: ACAP (2022).

Table A.3. | Summary of the EVs purchase barriers, determinants and advantages.

Barriers	Battery capacity/Driving range/Performance
	Charging infrastructures
	Prices
	Recharging duration
Determinants	Consumer's demographic characteristics
	Peer effects/Social influence
	Perceived benefit
	Technological consciousness
	Restriction/Incentive policies
Advantages	Environmental friendliness
	Low maintenance
	Low annual operational/maintenance costs
	Accessibility in cities (zero emissions zones)
	Comfort (no noises from the engine)
	Efficiency

Source: Author's elaboration, according to the cited authors.

Annex B | Applied survey[11]

Secção 1 de 7

⚡ Portuguese Awareness of Electric Vehicles' role on Energy Transition

Caro (a) participante,

O meu nome é João Gonçalves e convido-o (a) a participar neste questionário, que surge no âmbito de uma investigação para a minha dissertação de mestrado em Economia, na Iscte Business School, com a qual se pretende perceber o nível de consciência da população portuguesa sobre os impactos da utilização de veículos elétricos no contexto da Transição Energética que estamos a viver atualmente.

A sua participação é anónima e fundamental para obtenção de dados fidedignos e específicos, por forma a tecer inferências que se denotem relevantes para a área em estudo. A sua participação é totalmente voluntária, sendo que, escolhendo participar, poderá interromper o preenchimento do questionário a qualquer momento. Por outro lado, a confidencialidade das respostas é assegurada na sua plenitude, sendo que os resultados obtidos serão única e exclusivamente reportados para a investigação em curso, sem nunca existir menção a qualquer dado pessoal. Assim, peço, encarecidamente, que responda de forma sincera às próximas questões.

Para que possa participar, de acordo com os pré-requisitos da investigação, terá de ser portador de carta de condução e viver em Portugal. O questionário não demorará mais de 7 minutos.

Desde já, agradeço o seu interesse e participação no estudo.

Para qualquer esclarecimento adicional, não hesite em contactar-me através do endereço eletrónico: jfvgs@iscte-iul.pt.

Aceito participar no estudo. *

- ○ Sim, aceito e responderei às questões de uma forma sincera.

[11] The survey is available at: https://forms.gle/kzjYZLYs264PhCU49

Atenção aos Veículos Elétricos

Nesta secção, ser-lhe-ão colocadas questões sobre Veículos Elétricos. A considerar, para resposta às mesmas:
- Veículos Elétricos (VEs) - veículos movidos através de um motor elétrico, em vez de um motor de combustão interna, sendo que o motor elétrico utiliza a energia armazenada nas baterias.
- Veículos Convencionais (VCs) - veículos movidos através de um motor de combustão interna, tendo como energia base o gasóleo, a gasolina ou o gás (GPL).

Possui ou faz leasing de algum deste tipo de veículos? *

- ○ Veículo Elétrico
- ○ Veículo Convencional (Gasóleo, Gasolina, Gás)
- ○ Não possuo/faço leasing de nenhum veículo

Se respondeu "Veículo Elétrico" na última questão, quantos?

- ○ 1
- ○ 2
- ○ 3 ou mais

De um modo geral, qual o seu nível de interesse pelos VEs? *

	1	2	3	4	5	6	
Nada interessado	○	○	○	○	○	○	Extremamente interessado

Indique, na escala disponível, o quão forte seria a probabilidade de numa futura aquisição de viatura, vir a optar por um VE. *

	1	2	3	4	5	6	
Nada provável	○	○	○	○	○	○	Extremamente provável

Na hipótese de vir a comprar um VE, qual dos seguintes tipos lhe parece mais interessante? *

- ○ Veículos Elétricos a Bateria
- ○ Veículos Elétricos Híbridos Plug-in
- ○ Veículos Elétricos Híbridos
- ○ Veículos Elétricos Híbridos "Fuel Cell"
- ○ Veículos Elétricos de Longo Alcance

Quais considera serem as principais vantagens/benefícios dos VEs? *

- ☐ Zero emissões de gases para a atmosfera
- ☐ Melhor acessibilidade nos centros urbanos
- ☐ Menor custo de abastecimento
- ☐ Ausência de barulho do motor
- ☐ Isenção de impostos (ISV e IUC)

Caso estivesse a considerar a aquisição de um VE, quais seriam as suas maiores preocupações, considerando desvantagens e barreiras? *

- ☐ Infraestruturas de carregamento
- ☐ Tempo de carregamento total
- ☐ Reduzida autonomia
- ☐ Preço
- ☐ Custos operacionais/de manutenção anuais

Conhecimento sobre os Veículos Elétricos

Nesta secção, irão surgir algumas afirmações feitas sobre os Veículos Elétricos. Pedimos que, para cada afirmação, indique o seu grau de concordância com a mesma.

O desempenho de um VE é similar ao de um veículo convencional. *

	1	2	3	4	5	6	
Discordo fortemente	○	○	○	○	○	○	Concordo fortemente

Os VEs são extremamente seguros. *

	1	2	3	4	5	6	
Discordo fortemente	○	○	○	○	○	○	Concordo fortemente

Os VEs são mais silenciosos do que os outros veículos. *

	1	2	3	4	5	6	
Discordo fortemente	○	○	○	○	○	○	Concordo fortemente

Os VEs apresentam uma excelente aceleração. *

	1	2	3	4	5	6	
Discordo fortemente	○	○	○	○	○	○	Concordo fortemente

Os VEs são "amigos do ambiente" porque têm zero emissões e a sua utilização mundial reduzirá a poluição do ar, com impactos muito positivos no clima e na Transição Energética. *

	1	2	3	4	5	6	
Discordo fortemente	○	○	○	○	○	○	Concordo fortemente

O custo de carregar um VE é muito menor do que os custos do abastecimento de um veículo convencional. *

	1	2	3	4	5	6	
Discordo fortemente	○	○	○	○	○	○	Concordo fortemente

Os VEs custam, praticamente, o mesmo que os veículos convencionais. *

	1	2	3	4	5	6	
Discordo fortemente	○	○	○	○	○	○	Concordo fortemente

A tecnologia dos VEs amadureceu e, agora, têm um muito melhor alcance. *

	1	2	3	4	5	6	
Discordo fortemente	○	○	○	○	○	○	Concordo fortemente

Hoje, é mais fácil carregar os VEs, dado que existem mais estações de carregamento. *

	1	2	3	4	5	6	
Discordo fortemente	○	○	○	○	○	○	Concordo fortemente

É mais fácil ter um VE, porque já há mais possibilidades de o carregar em contexto doméstico. *

	1	2	3	4	5	6	
Discordo fortemente	○	○	○	○	○	○	Concordo fortemente

Tornou-se mais fácil adquirir um VE, porque existem para venda em segunda mão/semi-novos. *

	1	2	3	4	5	6	
Discordo fortemente	○	○	○	○	○	○	Concordo fortemente

Comparando com um veículo convencional, um VE é mais barato a longo prazo. *

	1	2	3	4	5	6	
Discordo fortemente	○	○	○	○	○	○	Concordo fortemente

Os VEs têm uma atenção especial do Estado, considerando os incentivos implementados. *

	1	2	3	4	5	6	
Discordo fortemente	○	○	○	○	○	○	Concordo fortemente

Os incentivos à aquisição de VEs aumentaram e são mais significativos. *

	1	2	3	4	5	6	
Discordo fortemente	○	○	○	○	○	○	Concordo fortemente

Não há necessidade de pagamento de parquímetro em locais públicos, o que facilita o uso diário dos VEs. *

	1	2	3	4	5	6	
Discordo fortemente	○	○	○	○	○	○	Concordo fortemente

É possível que tenha mais problemas mecânicos com um VE do que com um veículo convencional. *

	1	2	3	4	5	6	
Discordo fortemente	○	○	○	○	○	○	Concordo fortemente

Os custos de manutenção dos VEs são menores dos que os custos de manutenção dos veículos convencionais. *

	1	2	3	4	5	6	
Discordo fortemente	○	○	○	○	○	○	Concordo fortemente

Diga, por favor, o nome de dois modelos de VEs. *

Texto de resposta curta

Quantos modelos de VEs acredita que estejam disponíveis para venda? *

- 5 ou menos
- 6 - 10
- 11 - 20
- 21 - 30
- Mais de 30

Comparando com um veículo convencional, quanto pensa que custa um VE novo? *

- Pelo menos 50% mais barato
- Entre 10% a 50% mais barato
- Praticamente o mesmo valor
- Entre 10% a 50% mais caro
- Pelo menos 50% mais caro

Concorda que deveriam existir mais VEs em circulação nas estradas? *

	1	2	3	4	5	6	
Discordo fortemente	○	○	○	○	○	○	Concordo fortemente

Como pensa que se abastece um Veículo Elétrico Híbrido? *

- ○ Abastecimento apenas com gasolina.
- ○ Abastecimento apenas com eletricidade, através da ligação a uma estação de carga/tomada doméstica.
- ○ Abastecimento tanto com gasolina ou eletricidade, através da ligação a uma estação de carga/tomada ...
- ○ Abastecimento com uma mistura de hidrogénio e oxigénio.
- ○ Não sei/Não respondo

Como pensa que se abastece um Veículo Elétrico a Bateria? *

- ○ Abastecimento com uma mistura de hidrogénio e oxigénio.
- ○ Abastecimento tanto com gasolina ou eletricidade, através da ligação a uma estação de carga/tomada ...
- ○ Abastecimento apenas com gasolina.
- ○ Abastecimento apenas com eletricidade, através da ligação a uma estação de carga/tomada doméstica.
- ○ Não sei/Não respondo

Como pensa que se abastece um Veículo Elétrico "Fuel Cell"? *

- ( ) Abastecimento apenas com eletricidade, através da ligação a uma estação de carga/tomada doméstica.
- ( ) Abastecimento apenas com gasolina.
- ( ) Abastecimento com uma mistura de hidrogénio e oxigénio.
- ( ) Abastecimento tanto com gasolina ou eletricidade, através da ligação a uma estação de carga/tomada ...
- ( ) Não sei/Não respondo

Qual(is) a(s) marca(s) em que mais confia para o desenvolvimento dos VEs? *

Texto de resposta curta

Consciência sobre o impacto dos Veículos Elétricos na Transição Energética

Descrição (opcional)

Na sua opinião, qual seria o melhor tipo de VE a utilizar no contexto de Transição Energética? *

- ○ Veículos Elétricos a Bateria
- ○ Veículos Elétricos Híbridos Plug-in
- ○ Veículos Elétricos Híbridos
- ○ Veículos Elétricos Híbridos "Fuel Cell"
- ○ Veículos Elétricos de Longo Alcance

Mediante a sua resposta na pergunta anterior, justifique, por favor. *

Texto de resposta longa

Considera que os VEs são importantes para a Transição Energética? *

- ○ Sim
- ○ Não

Mediante a sua resposta na pergunta anterior, justifique, por favor. *

Texto de resposta longa

Estaria disposto a mudar a sua atitude face à mobilidade, para aumentar a utilização de VEs? *

- ◯ Sim
- ◯ Não

Se respondeu "Sim" à última questão, diga como, por favor.

Texto de resposta longa

Qual das seguintes afirmações descreve melhor a sua opinião face ao desenvolvimento dos VEs? *

- ◯ Não tenho ideia de como está o desenvolvimento dos Veículos Elétricos, pois não considero que sejam ...
- ◯ Considero que podem ter um impacto positivo na Transição Energética, embora não sejam o fator-chave...
- ◯ Penso que são um elemento importante no contexto atual e acompanho, pontualmente, o seu desenvolv...
- ◯ Acredito que já são o nosso presente e que têm uma papel crítico na Transição Energética, já que o seto...
- ◯ Não tenho interesse no tema/Não respondo.

Caracterização Sociodemográfica

Descrição (opcional)

Qual é a sua idade? *

- 18 - 30 anos
- 31 - 40 anos
- 41 - 50 anos
- 51 - 60 anos
- > 61 anos

Qual é a sua área de residência? *

- Região Norte
- Região Centro
- Região de Lisboa e Vale do Tejo
- Região do Alentejo
- Região do Algarve
- Região Autónoma dos Açores
- Região Autónoma da Madeira

Tem carta de condução? *

- Sim
- Não

Qual é o seu último grau académico completo? *

- Ensino Básico (1º ao 9º ano)
- Ensino Secundário (12º ano)/Ensino Profissional
- Licenciatura/Bacharelato
- Mestrado/Pós-Graduação
- Doutoramento

Qual é a sua ocupação? *

- Trabalhador por conta de outrem
- Trabalhador por conta própria
- Trabalhador-Estudante
- Estudante
- Desempregado
- Reformado

Qual é o nível de rendimento líquido total mensal no seu agregado familiar? *

- ( ) Menos de 1000€
- ( ) Entre 1000€ a 2000€
- ( ) Entre 2000€ e 3500€
- ( ) Mais de 3500€
- ( ) Prefiro não revelar

Quantos dias por semana utiliza carro? *

- ( ) Todos os dias
- ( ) 5 a 6 dias
- ( ) 3 a 4 dias
- ( ) 1 a 2 dias
- ( ) Não utilizo carro

Annex C | Sample Characterization

Table C.1. | Answers to the question "Qual é a sua idade?"

Age	Absolute Freq.	%
18 - 30 years	87	57.6%
31 - 40 years	37	24.5%
41 - 50 years	15	9.9%
51 - 60 years	10	6.6%
> 61 years	2	1.3%
Total	**151**	**100%**

Source: Author's elaboration.

Table C.2. | Answers to the question "Qual é a sua área de residência?"

Residence Area	Absolute Freq.	%
Norte zone	14	9.3%
Centro zone	13	8.6%
Lisboa e Vale do Tejo	101	66.9%
Alentejo	7	4.6%
Algarve	5	3.3%
Açores	7	4.6%
Madeira	4	2.6%
Total	**151**	**100%**

Source: Author's elaboration.

Table C.3. | Answers to the question "Qual é o seu último grau académico completo?"

Education	Absolute Freq.	%
Primary education	5	3.3%
High school/Vocational education	20	13.2%
BSc	72	47.7%
MSc/Postgraduate	51	33.8%
PhD	3	2.0%
Total	**151**	**100%**

Source: Author's elaboration.

Table C.4. | Answers to the question "Qual é a sua ocupação?"

Occupation	Absolute Freq.	%
Dependent worker	106	70.2%
Self-employed	12	7.9%
Working-student	12	7.9%
Student	19	12.6%
Unemployed	2	1.3%
Retired	0	0.0%
Total	**151**	**100%**

Source: Author's elaboration.

Table C.5. | Answers to the question "Qual é o nível de rendimento líquido total mensal no seu agregado familiar?"

Household Income	Absolute Freq.	%
< 1000€	20	13.2%
1000€ < 2000€	51	33.8%
2000€ < 3500€	42	27.8%
> 3500€	23	15.2%
Prefer not to reveal	15	9.9%
Total	**151**	**100%**

Source: Author's elaboration.

Table C.6. | Answers to the question "Quantos dias por semana utiliza carro?"

Frequency of Car Use	Absolute Freq.	%
Every day	39	25.8%
5 to 6 days	27	17.9%
3 to 4 days	39	25.8%
1 to 2 days	30	19.9%
Doesn't use car	16	10.6%
Total	**151**	**100%**

Source: Author's elaboration.

Table C.7. | Answers to the question "Possui ou faz leasing de algum deste tipo de veículos?"

Vehicle Possession	Absolute Freq.	%
Electric Vehicle	9	6.0%
Conventional Vehicle	93	61.6%
Does not own/lease any vehicle	49	32.5%
Total	**151**	**100%**

Source: Author's elaboration.

Annex D | To what extent are the Portuguese conscious about EVs?

Table D.1. | Answers to the question "Qual das seguintes afirmações descreve melhor a sua opinião face ao desenvolvimento dos VEs?"

Opinion towards EVs	Absolute Freq.	%
"Não tenho ideia de como está o desenvolvimento dos Veículos Elétricos, pois não considero que sejam uma mais-valia para os portugueses, no contexto nacional. Na minha opinião, deveria continuar a ser dada prioridade aos Veículos Convencionais."	5	3.3%
"Considero que podem ter um impacto positivo na Transição Energética, embora não sejam o fator-chave. Não acompanho a evolução destes veículos, mas reconheço que a utilização dos Veículos Convencionais é prejudicial para o ambiente em alguns aspetos."	42	27.8%
"Penso que são um elemento importante no contexto atual e acompanho, pontualmente, o seu desenvolvimento, porém não tenho interesse em adquirir um para já, dado que considero que ainda existem algumas barreiras, quando comparados com os Veículos Convencionais, apesar de reconhecer as suas vantagens e benefícios."	62	41.1%
"Acredito que já são o nosso presente e que têm uma papel crítico na Transição Energética, já que o setor dos transportes é um dos que mais polui, e, com estes, conseguiremos passar a utilizar mais energias renováveis, o que constituirá um marco crucial na transição. Acompanho a evolução deste tipo de veículos ao pormenor e já tenho um/estou a pensar adquirir numa próxima compra."	39	25.8%
"Não tenho interesse no tema/Não respondo."	3	2.0%
Total	**151**	**100%**

Source: Author's elaboration.

Table D.2. | Answers to question “Como pensa que se abastece um Veículo Elétrico Híbrido?”

Type of Fuel	Absolute Freq.	%
Gasoline	19	12.6%
Electricity	1	0.7%
Gasoline/Electricity	121	80.1%
Hydrogen/Oxygen	1	0.7%
Don’t know/Don’t answer	9	6.0%
Total	**151**	**100%**

Source: Author's elaboration.

Table D.3. | Answers to question “Como pensa que se abastece um Veículo Elétrico a Bateria?”

Type of Fuel	Absolute Freq.	%
Gasoline	0	0%
Electricity	137	90.7%
Gasoline/Electricity	5	3.3%
Hydrogen/Oxygen	0	0%
Don’t know/Don’t answer	9	6.0%
Total	**151**	**100%**

Source: Author's elaboration.

Table D.4. | Answers to question “Como pensa que se abastece um Veículo Elétrico "Fuel Cell"?”

Type of Fuel	Absolute Freq.	%
Gasoline	5	3.3%
Electricity	16	10.6%
Gasoline/Electricity	9	6.0%
Hydrogen/Oxygen	48	31.8%
Don’t know/Don’t answer	73	48.3%
Total	**151**	**100%**

Source: Author's elaboration.

Table D.5. | Answers to question "Os VEs são mais silenciosos do que os outros veículos."

Level (Strongly Disagree – Strongly Agree)	Absolute Freq.	%
1	0	0%
2	0	0%
3	3	2.0%
4	6	4.0%
5	23	15.2%
6	119	78.8%
Total	**151**	**100%**

Source: Author's elaboration.

Table D.6. | Answers to question "A tecnologia dos VEs amadureceu e, agora, têm um muito melhor alcance."

Level (Strongly Disagree – Strongly Agree)	Absolute Freq.	%
1	1	0.7%
2	5	3.3%
3	21	13.9%
4	47	31.1%
5	53	35.1%
6	24	15.9%
Total	**151**	**100%**

Source: Author's elaboration.

Table D.7. | Answers to question "Os VEs são "amigos do ambiente" porque têm zero emissões e a sua utilização mundial reduzirá a poluição do ar, com impactos muito positivos no clima e na Transição Energética."

Level (Strongly Disagree – Strongly Agree)	Absolute Freq.	%
1	2	1.3%
2	6	4.0%
3	19	12.6%
4	36	23.8%
5	41	27.2%
6	47	31.1%
Total	**151**	**100%**

Source: Author's elaboration.

Table D.8. | Answers to question "O custo de carregar um VE é muito menor do que os custos do abastecimento de um veículo convencional."

Level (Strongly Disagree – Strongly Agree)	Absolute Freq.	%
1	2	1.3%
2	10	6.6%
3	28	18.5%
4	33	21.9%
5	36	23.8%
6	42	27.8%
Total	**151**	**100%**

Source: Author's elaboration.

Table D.9. | Answers to question "Não há necessidade de pagamento de parquímetro em locais públicos, o que facilita o uso diário dos VEs."

Level (Strongly Disagree – Strongly Agree)	Absolute Freq.	%
1	6	4.0%
2	13	8.6%
3	30	19.9%
4	34	22.5%
5	30	19.9%
6	38	25.2%
Total	**151**	**100%**

Source: Author's elaboration.

Table D.10. | Most expressive answers to question "Diga, por favor, o nome de dois modelos de VEs.", with their prices, according to official websites, comparing with the average price of a CV in Portugal.

Models	Price	Average price of a CV
Renault Zoe	> 33.550 €	20.000€
Nissan Leaf	> 27.900 €	
Tesla Model 3	> 54.990 €	
Tesla Model X	> 145.990 €	

Source: Author's elaboration, according to Renault, Nissan, Tesla and Dinheiro Vivo official websites.

Table D.11. | Answers to question "Comparando com um veículo convencional, quanto pensa que custa um VE novo?"

Prices	Absolute Freq.	%
At least 50% cheaper	1	0.7%
Between 10% to 50% cheaper	4	2.6%
About the same value	5	3.3%
Between 10% to 50% more expensive	116	76.8%
At least 50% more expensive	25	16.6%
Total	**151**	**100%**

Source: Author's elaboration.

Table D.12. | Answers to question "Os incentivos à aquisição de VEs aumentaram e são mais significativos."

Level (Strongly Disagree – Strongly Agree)	Absolute Freq.	%
1	5	3.3%
2	13	8.6%
3	44	29.1%
4	48	31.8%
5	33	21.9%
6	8	5.3%
Total	**151**	**100%**

Source: Author's elaboration.

Annex E | Are the EVs perceived as critical for the energy transition, by the Portuguese population?

Table E.1. | Answers to the question "Considera que os VEs são importantes para a Transição Energética?"

Importance	Absolute Freq.	%
No	12	7.9%
Yes	139	92.1%
Total	**151**	**100%**

Source: Author's elaboration.

Table E.2. | Answers to question "Os VEs são "amigos do ambiente" porque têm zero emissões e a sua utilização mundial reduzirá a poluição do ar, com impactos muito positivos no clima e na Transição Energética."

Level (Strongly Disagree – Strongly Agree)	Absolute Freq.	%
1	2	1.3%
2	6	4.0%
3	19	12.6%
4	36	23.8%
5	41	27.2%
6	47	31.1%
Total	**151**	**100%**

Source: Author's elaboration.

Table E.3. | Answers to the question "De um modo geral, qual o seu nível de interesse pelos VEs?"

Level (No Interest – Extremely Interested)	Absolute Freq.	%
1	6	4.0%
2	6	4.0%
3	24	15.9%
4	39	25.8%
5	37	24.5%
6	39	25.8%
Total	**151**	**100%**

Source: Author's elaboration.

Table E.4. | Answers to question "Os incentivos à aquisição de VEs aumentaram e são mais significativos."

Level (Strongly Disagree – Strongly Agree)	Absolute Freq.	%
1	5	3.3%
2	13	8.6%
3	44	29.1%
4	48	31.8%
5	33	21.9%
6	8	5.3%
Total	**151**	**100%**

Source: Author's elaboration.

Table E.5. | Answers to question "Não há necessidade de pagamento de parquímetro em locais públicos, o que facilita o uso diário dos VEs."

Level (Strongly Disagree – Strongly Agree)	Absolute Freq.	%
1	6	4.0%
2	13	8.6%
3	30	19.9%
4	34	22.5%
5	30	19.9%
6	38	25.2%
Total	**151**	**100%**

Source: Author's elaboration.

Table E.6. | Answers to question "Concorda que deveriam existir mais VEs em circulação nas estradas?"

Level (Strongly Disagree – Strongly Agree)	Absolute Freq.	%
1	1	0.7%
2	3	2.0%
3	11	7.3%
4	30	19.9%
5	47	31.1%
6	59	39.0%
Total	**151**	**100%**

Source: Author's elaboration.

Annex F | Is there a sense of inner change in the Portuguese population, regarding EVs adoption in the context of energy transition?

Table F.1. | Answers to the question "Estaria disposto a mudar a sua atitude face à mobilidade, para aumentar a utilização de VEs?"

Availability	Absolute Freq.	%
No	62	41.1%
Yes	89	58.9%
Total	**151**	**100%**

Source: Author's elaboration.

Table F.2. | Answers to the question "De um modo geral, qual o seu nível de interesse pelos VEs?"

Level (No Interest – Extremely Interested)	Absolute Freq.	%
1	6	4.0%
2	6	4.0%
3	24	15.9%
4	39	25.8%
5	37	24.5%
6	39	25.8%
Total	**151**	**100%**

Source: Author's elaboration.

Table F.3. | Answers to the question "Indique, na escala disponível, o quão forte seria a probabilidade de numa futura aquisição de viatura, vir a optar por um VE."

Level (No Probability – Extremely Likely)	Absolute Freq.	%
1	10	6.6%
2	23	15.2%
3	25	16.6%
4	30	19.9%
5	31	20.5%
6	32	21.2%
Total	**151**	**100%**

Source: Author's elaboration.